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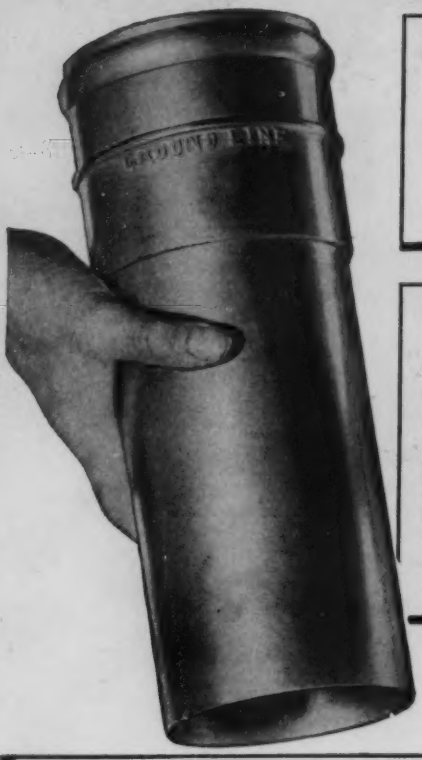
Abstracts—News of the Field

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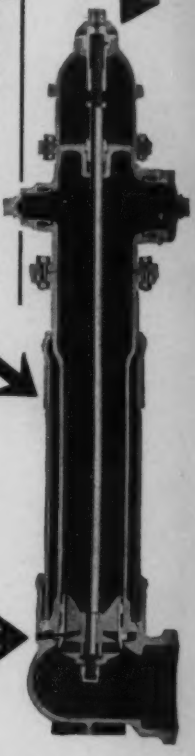


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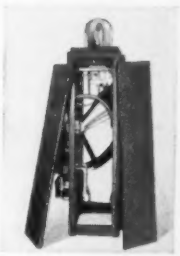
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Urban Domestic Water Consumption

By M. A. Pond

DURING the past half century many engineers have been concerned with the use of water for domestic purposes in urban areas, yet comparatively little recent information dealing with actual measured consumption has been assembled. Engineers engaged in planning extensions to water systems and those designing large scale housing developments are interested in making estimates of future water consumption and its probable effect on the engineering and the economic development of the utility. The material presented here may be useful in such planning. It must be emphasized at the outset that these data and conclusions pertain only to metered accounts in a few eastern cities, and that, where possible, local information on domestic water consumption should be used to supplement this more general statement.

Twenty gallons per capita daily has been estimated to be the absolute minimum amount of water needed to carry out properly the various functions of life (1). It allows 1 gallon for drinking, 6 for laundry, 5 for ablution (but without tub or shower), and 8 for two toilet flushes. Information gathered from various sources indicates that this should be considered as a minimum which is probably far exceeded in modern urban society.

A paper contributed by M. A. Pond, Instructor in Public Health, Department of Public Health, Yale University School of Medicine, New Haven, Conn.

For purposes of estimating the probable use of water in a given building the engineer considers those quantities which are used for specific domestic operations and which do not vary appreciably with size of family, as well as the basic consumption rate of 20 gallons per capita per day. The total amount of water used in sprinkling a lawn does not vary with the number of persons living in a given house, nor does the quantity used for washing the family car. On the other hand, the use of water for personal bathing is directly related to the number of persons in the household.

The figures which are presented here are subject to some variation but they may well serve as an index of the amounts which may reasonably be considered to be used in carrying out various domestic operations. Studies here and abroad have indicated that about one-half to two-thirds of the water used in ordinary household consumption is heated (bathing, laundering, dish-washing, etc.).

Operation	*Quantity of Water*
Tub bath	25 gallons/bath
Shower bath	5 gallons/min.
Additional toilet flush/person	6 gallons/diem
Sprinkling lawn ($\frac{5}{8}$-inch hose)	7 gallons/min.
Washing automobile	150 gallons
Basic quantity/person	20 gallons/diem

Two examples will illustrate the use of these data.

Example 1. A family of five persons is to build a single house on a lot 50 by 100 ft. in a fairly good neighborhood. They plan to have a bathtub and do home laundering, but they have no automobile. How much water per capita (in round numbers) should be estimated as the daily consumption for this family?

Basic figure $= 5 \times 20 = 100$ g.p.d.
Lawn watering = 20 min./diem for 3 mos. = 5 min./diem = 35 g.p.d.
Bathing—2 baths/week/person $= 5 \times 50/7$ = 35 g.p.d.
Total = 170 g.p.d.
Per capita consumption = 34 g.p.d.

Example 2. A family of three is to build a large house on a plot 125 by 250 ft. in an exclusive section of town. Laundering is to be done at home and the two cars probably will be washed twice a month at home. There is a shower for the head of the house, and two baths for the two women. What water consumption per capita could be estimated here?

Basic figure = 3 × 20 =	60 g.p.d.
Additional toilet flushes, 3 × 6 =	18 g.p.d.
Lawn watering 1 hour/day for 4 mos. = 20 mins./day for the year =	140 g.p.d.
Bathing—2 baths/day =	50 g.p.d.
Showers—10 min./diem =	50 g.p.d.
Washing cars—600 gal./mo. =	20 g.p.d.
Total	326 g.p.d.
Per capita consumption	109 g.p.d.

Similar methods of approach may be used in solving problems involving large apartments and housing projects.

City-Wide Domestic Consumption

Since water meters have been used in many cities for more than fifty years, engineers in planning for extensions of lines and other services have been able to utilize data gathered from studies of metered consumption. Brackett (2) in 1894, after gathering statistics on water consumption from several cities of Eastern Massachusetts, concluded that the quantity required for domestic use should not exceed 30 gallons per capita where premisses were generally metered. In 1902 Brackett (3) reconsidered his earlier studies and stated that it was improbable that the quantity needed would exceed 25 gal. per capita for many years to come. At this time he studied the relationship between rent and per capita consumption presenting figures to indicate that higher rents were associated with greater water consumption. Recent studies on economic status and water usage have corroborated these early findings.

Hill (4) studied water consumption in a typical, crowded, East Side tenement section of New York in 1903 and found that the average consumption per capita was 27.6 gal. per day in a population of 38,906 persons. DeVarona (5) found in a Brooklyn tenement district (1903) an average daily per capita consumption of 39 gal., while in a residential apartment house district in the Bronx the consumption was 43.5 gal. per capita daily. Fuertes (6) estimated that the purely domestic consumption of water in New York City in 1906 amounted to 30.2 gal. per capita per day.

Saville (7) has long been interested in water consumption characteristics and in 1915 conducted a study of water use at Hartford, finding that 33 gal. per capita daily was the average domestic consumption. In 1920 he found that the average consumption for 661 services

supplying nearly 6,000 persons was 34.4 gal. per capita with a range from 25.5 gal. in six-family tenements to 81.4 gal. for single houses.

In 1921, Fenkell (8) studied water consumption in Detroit and estimated that the actual domestic use of water after deducting losses due to leakage, carelessness, and other faulty conditions, amounted to 25.2 gal. per capita. This figure corresponds closely with that of a relatively high class residential area of Detroit studied at about the same time by Jones (9) who found the purely domestic consumption to be 29.6 gal. per capita daily.

TABLE 1

Average daily per capita domestic water consumption in gallons in certain eastern cities in the United States

CITY	YEAR	CONSUMPTION	CITY	YEAR	CONSUMPTION
		gal./cap./diem			*gal./cap./diem*
Brookline, Mass.	1892	44.3	Springfield, Mass.	1937	42
Newton, Mass.	1892	26.5	Hartford, Conn.	1938	40.0
Fall River, Mass.	1892	11.2	Paterson, N. J.	1938	42
Worcester, Mass.	1892	16.8	Clifton, N. J.	1938	41
Yonkers, N. Y.	1902	19.7	Passaic, N. J.	1938	44.5
New York City	1903	30.2	Syracuse, N. Y.	1938	30
Syracuse, N. Y.	1904	31.0	Dartmouth, Mass.	1938	33
Hartford, Conn.	1915	33	Acushnet, Mass.	1938	26
Hartford, Conn.	1920	34.4	Newark, N. J.	1938	36.4
West Haven, Conn.	1937	29			

Since 1921 the literature concerning domestic consumption has been sparse, although there are occasional notes on the quantities of water used by individual houses or by small groups of houses.

In table 1 are presented figures relating to average per capita domestic consumption in certain cities of the eastern United States. The early figures are quoted from published reports and engineering studies while those for 1937 and 1938 were kindly furnished in response to a questionnaire sent to different water departments. They represent the experience of the local water utility and are based on recorded meter consumption, or separate studies on domestic use of water. Many cities do not have available information on domestic water consumption. The range in average consumption for 1938 in different communities (26–44.5 g.c.d.) compares favorably at the

upper limit with the range found in earlier studies (11.2–44.3 g.c.d.). While there is a more lavish use of water in general, the average domestic use of water in cities is not much greater now than it was 45 years ago. Local increases such as are recorded for Hartford and Newark further bear this out. In 23 years the change has been only 7 gal. per capita per diem or about 20 per cent in Hartford, Conn., and in Newark, New Jersey, the increase in per capita domestic consumption for a period of 21 years has been about 12 per cent (32.6–36.4 g.c.d.). The figures for Syracuse indicate that there has been a diminished use of water for domestic purposes during the last 34 years (31.0–30.0 g.c.d.). It seems reasonable to assume that this comparatively slight change in the use of water despite a more lavish personal use may be due to wider acceptance of commercial laundry facilities, and to better control of leakage, coupled with more efficient plumbing.

From the data assembled in table 1 the following general conclusions may be drawn:

1. Each city has its own characteristic domestic water consumption figure, and care should be taken in applying general design data to any given community.

2. The minimum per capita daily domestic consumption of water for an urban community may be estimated as not less than 30 gal.

3. For design purposes, the daily per capita domestic consumption may be taken to be 40 gal., unless local figures are available from which a closer estimate may be made.

4. The increase in daily per capita domestic consumption may be estimated to be 1 per cent per year until a maximum of 50 gal. per capita is reached.

Variations Within the Community

Everyone who has studied the problem of domestic water consumption must be impressed with the variations found within a given community. Differences between tenement districts, apartment house sections, and areas where single houses predominate have frequently been pointed out. Brackett showed in 1894 that the consumption per capita for domestic use in Boston varied from 16.6 to 59 gal. per day, depending on the type of dwelling. More recently a limited survey in Washington, D. C., indicated a variation with type of residential section, daily average per capita consumption rates of 25, 35, 41, 50 and 56 gal. being found. These figures cor-

respond to data gathered in New Haven in 1937 when it was shown that for different areas of the city domestic consumption was 33.7, 35.6, 36.9, 37.7, 47.9, 56.5 and 84.8 gal. per capita, the three highest rates being found in the better class residential sections of the community. Griswold and Gentner (10) studied the relationship between domestic flow and meter registration, and data which they collected indicated that the range in consumption in high class residential districts of Hartford is at least 26–66 gal. per capita per day.

The wide ranges in per capita consumption noted in table 2 between sections and between types of dwellings within any community may well be explained on the basis of such factors as: number and type of plumbing fixtures, age and familial characteristics of consumers, watering of lawns and gardens, home laundering and automobile washing, and other similar conditions. For instance modern silent toilets use about 7 gallons of water per flush as compared with the 4 gallons discharged at each flush by the more common type of water-closet. Similarly automatic sprinklers used in watering lawns operate longer and at higher discharge rates than hand-directed hoses. White-collar workers despite a less obvious need are more likely to take daily baths than are day-laborers. Apartment house dwellers and those living in multiple-family houses do not have the same opportunity of washing their own cars as do people who live in single-family houses, and it is also probable that there is less car ownership in the former group. Home laundering is much less

TABLE 2

Variation in domestic per capita consumption within cities by districts

CITY	YEAR	RANGE
		g.c.d.
Boston, Mass.	1892	16–59
Worcester, Mass.	1892	12–23
Fall River, Mass.	1892	8–26
New York City	1903	27–140
Hartford, Conn.	1920	25–62
Hartford, Conn.	1932	26–66
New Haven, Conn.	1937	27–85
West Haven, Conn.	1937	28–75
Syracuse, N. Y.	1938	25–45
Boston Met. Dist., Mass.	1938	40–70
Washington, D. C.	1938	25–56

frequent in apartment houses than in any other type of dwelling unit. Such factors influence the amount of water that will be used in the household. In the following sections the cumulative effect of various factors will be apparent.

Water Consumption in Single Houses

It might well be expected that the average per capita consumption in single-family houses would normally exceed that of any other size of urban dwelling unit because the most lavish water users tend to live in single houses, their families are usually smaller, and their gardens and lawns more expansive.

Although few data are available a picture of average domestic water consumption in single-houses is given in table 3. The figures for West Haven, Conn., represent almost all single-houses in the town,

TABLE 3

Daily per capita water consumption in single-family houses

CITY	YEAR	NUMBER OF HOUSES	CONSUMPTION
			g.c.d.
Newton, Mass.	1892	490	26.5
Hartford, Conn.	1920	302	43.8
New Haven, Conn.	1937	1519	59.4
West Haven, Conn.	1937	3380	36.8

those for Hartford and Boston are taken from published reports, and the data for New Haven are representative of several sections of the community although they are weighted heavily by inclusion of considerable data covering the wealthiest residential sections of the city. The New Haven data are further broken down in table 4.

It is apparent that there is a wide range of rates of consumption within the city of New Haven. In almost every section represented in table 4 there is an explanation for either high or low consumption.

The data which have been presented indicate that water consumption within a community in single-family houses varies within wide limits for different sections, the minimum daily consumption being about 35 gal. per capita, and the maximum being more than 100 gal. per capita. The average domestic consumption is dependent largely upon local conditions and generalizations are hazardous.

Water Use in Multiple-Family Dwellings

As might reasonably be expected, the per capita domestic consumption of water is less in multiple-family houses (other than apartments and housing projects) than in single houses, and the range within communities is also smaller. In table 5 are presented data for four eastern cities at different times. The much more even distribution of rates of consumption than that found for general consumption between cities may well be due to the closely comparable character-

TABLE 4

Domestic water consumption in single-family houses of New Haven, 1937

DISTRICT	ECONOMIC STATUS	NUMBER OF HOUSES	AVERAGE (U. S. CENSUS) FAMILY SIZE IN PERSONS	CONSUMPTION
				g.c.d.
A	Good	335	3.77	38.0
B	Fair	470	3.82	33.9
C	Fair	176	2.92	39.0
D	Excellent	162	3.20	85.0
E	Poor	20	4.34	54.0
F	Good	66	3.07	55.7
G	Excellent	290	3.13	125.0

TABLE 5

Water consumption in multiple-family dwellings other than apartments

CITY	YEAR	NUMBER OF HOUSES	CONSUMPTION
			g.c.d.
Boston	1902	169	29.6
Hartford	1920	350	28.7
New Haven	1937	1407	39.4
West Haven	1937	1268	33.9

istics of two-, three-, and four-family houses in all of these communities over long periods of time.

In table 6 the data for two-, three-, and four-family houses are given by district (as in table 4) and by house size. The general uniformity between houses in the same region except for a few exceptions is notable. In all districts except *B* and *C* the average per capita consumption in single-family dwellings exceeds that for all multiple-family houses within the same districts

Water consumption per capita in two-, three-, and four-family houses is subject to somewhat less variation than for single houses, but the minimum daily rate should be estimated to be not less than 35 gal. The average daily per capita consumption for this type of dwelling should be estimated to be 40 gal.

TABLE 6

Consumption in New Haven (1937) by areas for multiple family-dwellings

DISTRICT	ECONOMIC STATUS	CONSUMPTION, G.C.D.		
		2-family	3-family	4-family
A	Good	27.5	37.6	27.0
B	Fair	31.0	31.9	36.7
C	Fair	37.0	38.6	45.9
D	Excellent	39.7	42.2	43.1
E	Poor	34.2	35.7	29.3
F	Good	42.3	51.2	44.6
G	Excellent	44.2	41.6	52.0

TABLE 7

Domestic water consumption in apartment houses of Bridgeport, 1938

APARTMENT	NUMBER OF FAMILIES	CONSUMPTION
		g.c d.
A	74	50.3
B	47	50.7
C	50	60.2
D	26	69.5
E	26	62.9
F	70	40.5
G	115	62.2
H	179	44.9
I	24	53.5
J	14	60.2
K	13	52.9

Consumption in Apartment Houses

In 1906, Fuertes showed that the consumption of water in apartment houses varied tremendously in different sections of New York City, ranging from 43.5 to 170 gal. per capita daily. More recent studies in other cities have indicated that similar variations are to be expected. In table 7 data are presented for the average daily per

capita consumption of water for 11 apartment houses in Bridgeport, Conn., during 1938. Four New Haven apartment houses located in different sections of the city during 1938 had per capita consumptions of 41.9, 68.0, 77.7 and 87.2 gallons per day. Tenants in 34 apartment houses in West Haven used an average of 75 gal. per capita daily during 1937.

There are at least two important reasons for the excessive rate of water consumption in apartment houses as compared with other types of dwellings: long hot-water pipe-lines and central metering. As has already been stated hot water represents about two-thirds of the total water consumed domestically. In most apartment houses, water is centrally heated. Consequently many tenants live at relatively great distances from the boiler, and a comparatively large amount of cold water coming through hot water faucets flows to waste. A possible remedy may be found in insulating hot water pipes, by providing for steam heating of water, or by using local hot water storage tanks around the building. Central metering, as far as the individual householder is concerned, means unlimited consumption since there is no incentive to conserve water in order to limit bills.

In designing the water supply systems of apartment houses the engineer may safely plan on a per capita consumption of 75 gal. daily. Obviously a large amount of water is being wasted at 75 gal. per capita, and by properly designing the hot water supply system the per capita consumption may be well below this figure. Individual meters are impractical when water is centrally heated not only because duplication on each apartment service would be necessary, but also because it is impossible to meter hot water satisfactorily.

Housing Projects and Domestic Water Consumption

Low-cost housing projects present a new type of problem for the designing engineer. Here there is no long experience available for obtaining data, although estimates are based on the recorded use at certain projects already built. That this approach should be taken cautiously is obvious since water consumption characteristics vary so widely from place to place.

The water consumption (shown in table 8) for three housing projects in Bridgeport, Conn., during the year 1938 were 33.7, 52.2 and 59.2 gal. per diem respectively, while for eight U. S. Housing Author-

ity projects in the east and mid-west the consumption varied from 36.3 to 90.9 g.c.d. Seven of the eight projects had less than 52 g.c.d. consumption rates.

Figures available for hot water consumption in 7 projects of the New York State Housing Board indicate that there is a range from 23 to 36 gal. per capita daily. If the hot water represents approximately two-thirds of all water used, the total domestic consumption varies between 35 and 54 gal. per capita. The average hot water consumption for the seven projects was 28 gal. per capita or a total water consumption of 42 gal. per person per day.

The same arguments concerning excessive water usage pertain here as they do when applied to apartment houses. The provision

TABLE 8

Domestic water consumption in housing projects (1938)

CITY	CONSUMPTION
	g.c.d.
Bridgeport, Conn. A	33.7
Bridgeport, Conn. B	52.2
Bridgeport, Conn. C	59.2
Boston, Mass.	37.3
Buffalo, N. Y.	40.1
Charleston, S. C.	36.3
Cleveland, Ohio	90.9
Indianapolis, Ind.	47.8
Louisville, Ky.	50.2
Milwaukee, Wis.	46.2
Oklahoma City, Okla.	51.3

of a single cold water pipe to each apartment with individual metering and local heating of water by gas by the tenant will promote water conservation. Substantial savings in the cost of piping will result from this practice, although the initial cost of individual gas-heaters probably will exceed that for central water-heaters. Fuel costs also will be higher. It may be possible for the management to create attitudes among project-dwellers which will cause them to conserve water so as to cut down on their rents.

At any rate, existing data indicate that 45 gal. per capita per diem is a reasonable design figure to use in planning housing projects although with adequate safeguards against wastage the per capita use should not exceed 40 gal. per diem.

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Discussion by *Roger W. Esty.* * Little has been written in the past about the amount of water that is used or required in small communities.

For several years we have made periodic flow tests of the Towns of Danvers and Middleton, and recently we have made some 24-hour tests of the amount of water used by the Town of Middleton.

Middleton, situated 20 miles north of Boston in Massachusetts, is a typical New England town. It is mainly a residential town with farming its chief industry. Situated in the southern part of the town, a mile beyond the water system, is an industrial plant which provides work for many of its residents. In the eastern part of the

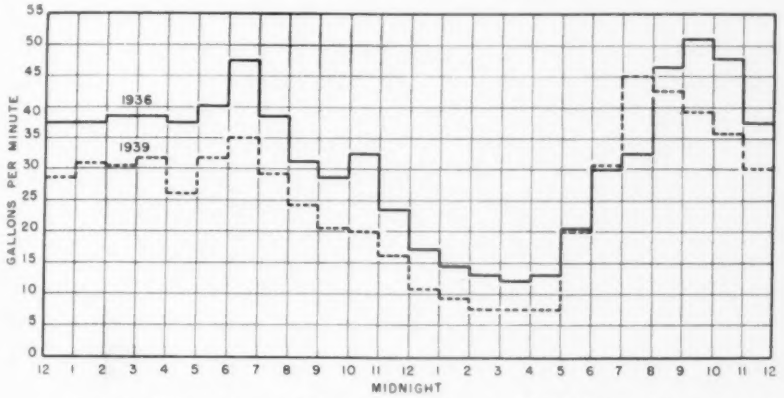


FIG. 1. Comparison of Demands in Town of Middleton, Mass.

town are two institutions, County and State, which also provide a means of livelihood for many others. However, in these tests these institutions and the industrial plant are not included.

The town is not entirely supplied by water, but there are 319 services supplying approximately 1,300 people. There are 8.49 miles of street pipes from 1 to 18 in. in diameter, and there are 35 fire hydrants

In examining the chart for 1936 one will note that the maximum consumption appeared between 9 and 10 in the morning, which amounts to 51.25 gallons per minute. This is near enough to call it a barrel per minute. The minimum appears to be between the hours of 3 and 4 A.M., amounting to 12.11 gal. per min. For 1939

* Superintendent, Water Department, Danvers, Mass.

the maximum demand appears between 7 and 8 in the morning, which amounted to 45 gal. per min. The minimum appeared between 2 and 5 in the morning, amounting to 7.5 gal. per min. Therefore, in tabulated form we have the following demands in gallons in the Town of Middleton for 1939 and 1936:

YEAR	PER MIN.	PER HOUR	PER DAY	PER CAPITA PER DAY
1939	25.78	1564.80	37,123.20	28.6
1936	31.98	1918.80	46,051.20	35.4

In 1936 only 36 per cent of the services were metered, and in 1939 they were 100 per cent metered. (See fig. 1.)

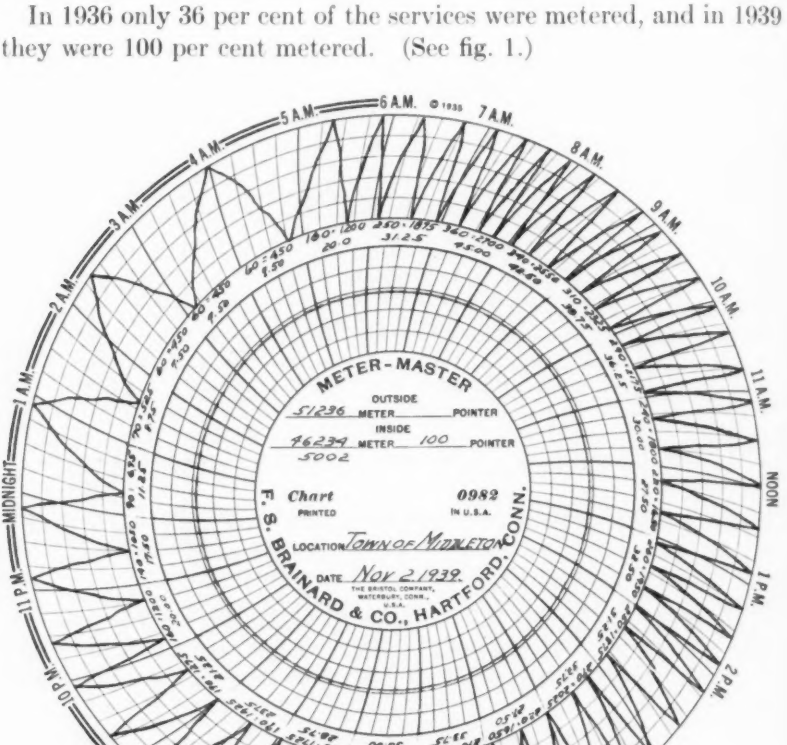


FIG. 2. Chart of 24-hour Demand. INTERPRETATION: from 8 A.M. to 9 A.M.—340 means cu. ft.; 2550 means gallons; and 42.50 means gal. per min.

These figures do not indicate maximum demand conditions as summer requirements are sometimes higher, and fire and flushing requirements add a little more to the demand. However, 15 per cent additional should more than take care of these requirements.

It may be interesting to know how these tests were made. We used a 2-inch disc meter which was connected to a 2-inch test tee (in a meter pit of one of the institutions) by a length of fire hose. From the outlet of the meter it required three lengths of fire hose to reach a hydrant. We connected a Meter Master to the register of the meter. That device records the rate of flow on a 24-hour chart. We then closed off the district which required the closing of two 18-inch gates, and one 12-inch gate, and then the water started to flow through the test meter.

We also used a Bristol recording gage which was connected on to the nearest hydrant. This indicated whether or not a sufficient amount of water was passing through the meter to take care of the demand and to hold up the pressure. In this instance there was a maximum drop in pressure of 4 pounds.

Arrangement was made with our station engineer to open up a gate if a fire occurred, and the chief of the fire department was notified that we were making a test.

The Hardest Nut Can Usually Be Cracked —In Public Relations—

Being a Play in One Act

By D. R. Taylor

CHARACTERS: MANAGER of the water department; CLERK; METER SERVICE MAN; and middle-aged male CUSTOMER.
SCENE: Any manager's office in any water department.

Scene 1

It is Tuesday afternoon—4:45 P.M.*—just before closing time. The* MANAGER *has had an unusually busy and trying day that has left his nerves frayed and his patience near an end. He is stacking aside on his desk papers and reports that he intends to take up again the following day, when he hears voices in the outer office and reception room off stage. A* CUSTOMER *has come in.*

CUSTOMER'S VOICE—I want to see the manager.

CLERK'S VOICE—Why certainly. Will you please have a seat for just a moment? Whom shall I say wishes to see him?

CUSTOMER'S VOICE—What difference does that make? Do you have to be the President of the United States to see the manager here?

CLERK'S VOICE—Why of course not; just a moment, please.

Enter CLERK.

CLERK—Mr. Brown, there is a gentleman in the front office who wishes to see you.

MANAGER—Do you know who he is, Miss Gray?

CLERK—No, I do not. When I asked him his name he asked if one had to be President of the United States to see the manager here.

MANAGER—Send him in, please.

A play presented on September 7, 1939 at the Virginia Section Meeting at Charlottesville, Va., by D. R. Taylor (*et al.*), Superintendent, Roanoke Water Works Co., Roanoke, Va.

Exit CLERK . . . . *Enter* CUSTOMER.

MANAGER—Good afternoon.

CUSTOMER—What do you people think you are trying to do down here?

MANAGER—I beg your pardon, I don't believe I follow you.

CUSTOMER—What is the idea of sending me such a bill? Do you think you are going to get away with that? Well I'll tell you right now that you are not—not for one minute. I've been living in this town for 35 years, and this is the highest bill I have ever received since I have been here, and it should have been the lowest. Now if you will make me up a correct bill for the water that I have actually used, I will be glad to pay it; otherwise I'm going right to the city council and show them just how the citizens of this city are being treated.

MANAGER—Won't you please have a seat, and I will be delighted to try to find out what is wrong with your bill. I don't believe I have had the pleasure of meeting you yet.

CUSTOMER—Smith is my name.

MANAGER—How do you do, Mr. Smith. I am exceedingly glad to meet you. Do you have your bill with you, Mr. Smith?

CUSTOMER—Yes—here it is.

MANAGER—Yes—$12.35 is rather above the average for a quarter. That would make your monthly bill slightly more than $4.30.

CUSTOMER—I don't know what the average is, but my bill usually runs about $6.75 per quarter or $2.25 per month; and if you can't give me a correct bill, I'll just go up and see the mayor, because I don't intend to be robbed in any such manner. I don't wash my automobile at home; we send our laundry out; and I do very little lawn sprinkling. There are only four in my family; yet there are six in the family next door, and they do all of their laundering at home, and their bill only runs $6.00 a quarter. I have a brother that lives in Terryburg, and he tells me that his water bill doesn't run but $1.50 a month, and he has the same number in his family that I have in mine.

MANAGER *presses button for clerk . . . . Enter* CLERK.

MANAGER—Miss Gray, will you bring me route book 27 please? Now, Mr. Smith, just one moment until I get the record of your account, and I am sure we will have no difficulty in locating the trouble.

CUSTOMER—Well I don't expect to pay such a bill as that. I

have known the city solicitor of this city intimately for 15 years, and if necessary I'll take this thing right to him.

Enter CLERK *with route book.* MANAGER *opens route book to proper account, which is shown by the folio number on the bill.*

MANAGER—Now, Mr. Smith, let's look at the record here and see what we find. Your consumption for the last quarter was 34,000 gallons, and I note that for the past two years your average has been only 15,500 gallons or slightly more than 5,000 gallons per month, which is about the average for the homes in your section. I do not find any record here showing that you have previously asked for an investigation of this high bill.

CUSTOMER—No, this is the first time I have said anything about it, and there is going to be an investigation before I pay it.

MANAGER—Mr. Smith, are you sure that you have no leaks in your plumbing?

CUSTOMER—Not a single one—you can go out there and look if you want to.

MANAGER—Mr. Smith, it will require a day or two for us to make the proper investigation of this apparent irregularity. May I ask that you leave your bill with me and also ask that you do not worry about this matter until you hear from me. You can rest assured that a very thorough investigation will be made, and the cause of this irregularity will be found. I wonder if it would be convenient for you to come in to see me sometime day after tomorrow.

CUSTOMER—Yes, I can come back day after tomorrow about 3:30 in the afternoon.

MANAGER—That will be fine. Now please forget that you received this bill, and please do not worry about it until I talk with you Thursday.

CUSTOMER—Before I pay such an outrageous bill as that I will spend a hundred dollars in court.

MANAGER—Mr. Smith, I can assure you that we will locate the trouble, and please do not worry any more about your bill until I talk with you Thursday.

Exit CUSTOMER. MANAGER *presses button for clerk. . . .* CLERK *enters.*

MANAGER—Miss Gray, will you please make a work order to install the recording register on Mr. Smith's meter? Here is the route book, and this is his account. Also please tell John to see me before going out on this job.

Scene 2

Same scene two hours later. Enter METER SERVICE MAN.

METER SERVICE MAN—Mr. Brown, Miss Gray said that you wanted to see me before I installed the recorder out in Clermont Heights.

MANAGER—Yes, John, while you are at this location I wish you would keep your eyes open and see if you notice anything—what hobbies Mr. Smith has.

METER SERVICE MAN—All right, Mr. Brown, I understand.

Exit METER SERVICE MAN.

Scene 3

Thursday afternoon—3:30 P.M. CUSTOMER *enters* MANAGER'S *office as curtain rises.*

MANAGER—Good afternoon, Mr. Smith. I am happy to see you.

CUSTOMER—What did you find?

MANAGER—Just have a seat. I have some rather interesting things to show you and tell you.

CUSTOMER—[*Rather stoically.*] Yeah. From the size of that bill it must be interesting.

MANAGER—Mr. Smith, here is a chart which shows your consumption from 9:00 A.M. yesterday to 9:00 A.M. this morning. I note that you are an early riser.

CUSTOMER—Yes, I have been getting up at six o'clock for years. I like to do a little work in the garden before breakfast.

MANAGER—Now, Mr. Smith, this little red line on this chart is figuratively speaking the life line of your family for one day. It indicates here that the first water was used for a short while at about 6:05 A.M., and here it is indicated that from about 6:30 until 7:15 breakfast was being prepared. I can tell by the rise of the red line. A straight line, Mr. Smith, indicates no consumption. A rise or fall indicates that water is being used, and the degree of inclination indicates the rate at which it was used. It is indicated there that your family had breakfast from 7:15 to 7:55, and a normal amount of water was used up to 11:00 A.M. Right here I would assume that the breakfast dishes were being washed, and the remainder of the consumption, which you will notice was periodic, was probably used during the normal house cleaning. The preparation of lunch was begun at 12:05. It is indicated that you had

lunch from 1:10 to 1:45. Apparently the lunch dishes were washed immediately after 2:00 P.M., and no water was used by your family from 3:00 until 5:00 P.M. except at 4:15 there is an indication here that a commode was flushed. Now, Mr. Smith, there are two indications here that may be of interest to you. The first is that someone flushed a commode this morning at 2:15 A.M.

CUSTOMER—I think you are wrong. Everybody in my house was in bed last night by 11:30, and I don't think anybody got up during the night. Let me use your 'phone a minute.

CUSTOMER—[*Over telephone.*] Mary, did you get up last night for anything? I am down at the water department office, and they are trying to tell me that someone flushed a commode at 2:15 this morning. [*Pause.*] Oh yes, James—I had forgotten about him. Yes, all right, thank you—Good-by.

CUSTOMER *hangs up receiver.*

CUSTOMER—My wife says that my son, James, went to a dance last night and came in about two o'clock this morning, so I guess it must have been he that flushed that commode.

MANAGER—The most outstanding indication on this chart, Mr. Smith, and one that you will be most interested in is that you have a rather bad leak in your plumbing. You will notice the gradual rise and fall of this line over the entire 24 hours that this chart was on. Those abrupt changes show that water was being used by your family, but the very gradual rise and fall indicates the leak. Right here you will notice it very plainly from 11:30 last night until six this morning when you arose.

CUSTOMER—I don't believe I have any such leak as that. If I did, I would have so much water around the place I would have to have a boat to get into the house. Why I couldn't use that much water if all my spigots were running wide open all of the time.

MANAGER—Mr. Smith, while our man was out there he located this leak for you with a very sensitive instrument that we use for such purposes, known as a geophone. He found the leak near your spigot in your garden. He noticed that someone had been dumping ashes at this point, and that was no doubt the cause of your leak. All ashes contain a certain amount of acid, and normal rains will wash this acid down into the ground, and the acid will very quickly eat up your pipe line. Now, Mr. Smith, if you will have this leak stopped, we shall be very glad to refund to you 50 per cent of your excess consumption. In other words we will pay one-half of your

loss if you will pay the other one-half, and we think that is a fair proposition. If you bought a gallon of milk and dropped it on the way home, your dairyman would expect you to pay for another gallon. We don't know of any other merchant in town who operates under such a liberal refund policy as we do; however we believe that it pays large dividends; we believe that you were unaware of this waste, and we are glad to share some of the expense with you. That would make your bill only $9.57.

CUSTOMER—I am surprised to learn that I had such a leak; however, everything that you have showed me and have told me has stacked up so well that I am afraid that you are right.

MANAGER—By the way, Mr. Smith, you live next door to Henry Green, Manager of the Telephone Company, don't you?

CUSTOMER—Yes, I do. I have known Henry for quite a long while. I hunt a little with Henry every fall.

MANAGER—I have heard about your dogs—our meter service man admired them very much. He told me that you had two very beautiful Irish Setters.

CUSTOMER—Yes, they are very good dogs. I bought them when they were puppies and trained them myself.

MANAGER—Are you a golfer, Mr. Smith?

CUSTOMER—No, my son plays the golf for the family. I hunt and fish for my recreation.

MANAGER—Does Henry fish with you too?

CUSTOMER—Yes, Henry is really a dyed-in-the-wool fisherman.

MANAGER—What kind of fishing do you and Henry do?

CUSTOMER—Well, Henry and I visit most of the mountain streams for mountain trout. The sportier they are the better I like them. We also try to get down to the coast and do a little salt water fishing once or twice during the summer. [*Rising.*] Well, I expect I had better go and have that leak attended to.

MANAGER—Just a minute, Mr. Smith, there are one or two other things I would like to tell you while you are here. When you came in the first day, you spoke of not washing your automobile at home, of sending your laundry out, and of doing very little lawn springling. It may surprise you to know that all three of those usages account for a very small portion of your water consumption. For instance, the average family uses only 1 per cent of its water for car washing, only 4 per cent for laundry, and about 3 per cent for lawn sprinkling, which you see is only 8 per cent of your total consumption.

CUSTOMER—Well, what are the larger percentages used for?

MANAGER—About 45 per cent is used for flushing toilets, 30 per cent for bathing and washing hands, and the remainder for drinking, cooking, household cleaning, and other miscellaneous uses. As a matter of fact, Mr. Smith, for a yard with a 50-foot front and the house setting back 50 feet, it requires 3,000 gallons of water to be equivalent to one inch of rain. The average lawn sprinkler runs about 5 gallons per minute, or 300 gallons per hour, and at our rate you can sprinkle your lawn for an hour for only 9 cents. You pay $600 per ton for coffee, $100 per ton for sugar, $60 per ton for flour, $20 per ton for salt, and $7 to $15 per ton for coal. Mr. Smith, you pay from $3 to $5 for a truck load of dirt for your rose bushes—yet you pay only 7.2 cents per ton for water—which is next to the air that you breathe in importance. You might live as long as three months without food, but without water you could live only a few days. Yet your water costs you only 3.6 cents per thousand pounds. Mr. Smith, the old saying "cheap as dirt" is a misnomer. It should be "cheap as water."

CUSTOMER—[*Rising again and extending his hand.*] Well, Mr. Brown, I want to thank you for looking into this matter for me. Those facts that you have just given me are very interesting. I was a little upset when I first came to see you about this bill, and I am afraid that I was influenced to a certain extent by one of my neighbor's lamentations. However, I should not have been, because he is a habitual complainer. I hope you will pardon my rudeness Tuesday.

MANAGER—Oh, don't worry about that, Mr. Smith, we are always happy to serve you in any way possible.

CUSTOMER—Good-by, Mr. Brown.

MANAGER—Good-by, Mr. Smith.

Exit CUSTOMER.

Scene 4

Same scene, next afternoon.

MANAGER—[*Answering his telephone.*] Hello, yes . . . why, hello, Mr. Smith! . . . So you found your leak without any difficulty. Well I am glad. . . . Did you say that your plumber had completed the job of repairing it? . . . Well, that's fine. . . . There is really no hurry about that. In that case we will get it in the morning's mail.

Do you want us to mail you a receipt? We will be glad to do so if you wish. . . . That's right, your check is a sufficient receipt. . . . No, I have no plans for Saturday afternoon. . . . I do fish occasionally. Since you mentioned it I believe the fishing season does open Saturday . . . Yes, that's right, Saturday is the 16th. . . . I would be delighted. . . . At 1:00 P.M.? Why yes, that would be convenient. . . . I would be glad to take my car. . . . Well that's mighty nice of you. . . . You will pick me up here at the office? . . . That's mighty fine, Mr. Smith; I am awfully happy to accept your invitation, and I will be ready promptly at one on Saturday. . . . Thank you. Good-by.

[*Curtain.*]

Epilogue

This was the beginning of a long friendship between Mr. Smith and Mr. Brown.

Conditions in this city are no different from conditions in your town or city. There are certain psychological conditions to bear in mind in settling any complaint. One must bear in mind that the consumer has planned his approach, his attack and his arguments for perhaps as long as two weeks; therefore if he is particularly unrelenting and uncompromising you cannot hope to break down his arguments and reach an amicable settlement with him in ten or fifteen minutes or even an hour. The slightest suggestion on your part of such a weakness on his part is an insult to his intelligence and a challenge to his pride.

Ask him to leave the bill with you; to forget that he even received it and above all not to worry about it until he sees you again at some pre-arranged time. Assure him that you and as many of your employees as are necessary will devote any amount of time necessary to investigate thoroughly the conditions of the complaint, that not a single stone will be left unturned and that no expense will be spared in obtaining all the facts. Then let him go home and sleep over the matter and cool off.

It has been said that Noah Webster was once upon a time caught by his wife hugging their maid. Mrs. Webster said "Why, Noah, I am surprised." Noah said, "No, dear, you're astonished; I am surprised."

Astonish your complaining consumer with your genuine pleasant interest and sincerity and surprise him with real facts and logical

reasoning. Try to kill him with kindness. Treat him as if he were the only consumer in the world. Try to find some common meeting ground with him during the interview to lessen the tension. Ask him about his family, his children, his bird dogs, his fishing, his golf, his garden, his roses, his civic work—anything that will start him talking about himself. This is like adding sugar to a sour lemonade. It doesn't take much to do a lot of good.

Your approach may vary, your solution may be slightly different in each case but with the same fundamentals you can make friends of ninety-nine per cent of your consumers.

Efficient Utilization of Water for Fire Fighting

By Clarence Goldsmith

THE first organized method of extinguishing fire was by bucket brigades; however, in the Fourth Century, B.C., large syringes were developed with a capacity sufficient to hold a gallon of water, and soon larger ones were constructed. Similar syringes were used in London, England, until the latter part of the Seventeenth Century; many of them are still preserved in the old parish churches. These were called "instrumentum ad jaculandas aquas adversus incendia," meaning instrument to throw water against fires.

In 1632 Thomas Grent patented an engine to throw water at fires. The machine had two cylinders and resembled the hand tub so familiar to our grandfathers. It was necessary to place the machine as close to the fire as possible in order to direct the stream on the fire. This necessitated feeding the suction box by a bucket brigade. It was not until late in the Seventeenth Century that the air chamber and hose were utilized, the former being invented by Van der Heyden in 1663. The first steam fire engine was developed by Braithwaite in 1830, and, in 1850, Latta built the first steam fire engine in Cincinnati, Ohio, where it was put in service. Early in 1870 self-propelled steam fire engines were built for New York, Boston, and Detroit. About 1910 the development of the automobile fire engine, as we know it today, commenced.

There are two methods of extinguishing a fire: first, by cooling; and, second, by excluding air. In most cases these are combined. Cooling the burning material is the most common form; it is the oldest and most generally effective. For fires of considerable magnitude, especially in free-burning materials such as are found in burning buildings, it is the only effective method. Water is the greatest cooling agent available in sufficient quantities. The amount of heat

A paper presented on April 25, 1939 at the Indiana Section Meeting at Indianapolis, Ind., by Clarence Goldsmith, Assistant Chief Engineer, The National Board of Fire Underwriters, Chicago, Ill.

absorbed by water in changing from liquid to vapor is ten times that of any other extinguishing agent.

Water can be applied in a number of ways, such as by hand, in a bucket, by pressure exerted upon it as with a pump or compressed gas, or by gravity from elevated storage. Small streams can be used for extinguishing little fires, and large, powerful streams for serious fires. It can be used in sprinkler systems as it lends itself readily to automatic control. It is true that the progress in the chemical industry has brought about the development of commercial quantities of carbon tetrachloride and carbon dioxide gases which are well adapted to fire extinguishment under certain conditions because they accomplish the exclusion of air. Some dry-powder extinguishers are also efficient under certain conditions. Water, however, will continue to be the predominant fire-extinguishing medium. Our problem then is to discuss its efficient utilization in fire fighting.

Water is now utilized in the extinguishment of fires by two methods. It is directed on the fire manually from fire pails or in small jets, fire streams, and sprays, each of which proves inefficient because in most cases only a small portion of the water reaches the seat of the fire and performs its function of quenching and extinguishment. Its automatic delivery from sprinkler systems is the most efficient method of application. The development of sprinkler heads commenced in the latter seventies of the previous century, and has been progressively continued since that time.

Operation of Sprinkler Systems

One of the most important parts of a sprinkler equipment is the sprinkler head itself. It is a metal device having an opening approximately one-half inch in diameter. Normally this opening is closed by means of a disc or seat which is held in place by a strut, or levers of metal. These are held under tension by a fusible link that melts or fuses at a predetermined temperature. There is a deflector attached to the frame in front of the opening which serves to distribute the water which is thrown against it with considerable force. The spray thus formed is distributed over the ceiling and floor area. The pipes supplying the sprinkler heads consist of interconnected piping located near or sometimes within the ceiling, the heads being attached to the outlets at more or less regular intervals. The spacing and the arrangement of these heads depend upon the construction and occupancy. Under ordinary conditions, only those heads above the fire operate.

An automatic sprinkler system performs three very important functions: first, detecting the fire; second, sounding the alarm; and, third, extinguishing the fire or holding it in check until other aid arrives. The fire is detected as soon as the head operates. This occurs when the heat from the fire melts the solder, allowing the head to open. As soon as there is a flow of water from the head, an electric contact is made or a water motor gong operates, sounding the alarm.

A pressure of 12 pounds on the highest pipe line supplying sprinklers should be available when 500 gallons of water per minute are being withdrawn from the underground system supplying the equipment. This requirement of flow is minimum for equipments having 200 heads or less in one fire area. Larger areas will require additional flow in gallons a minute. It is assumed that 25 heads may open in any one fire area, and that each head will discharge approximately 20 gallons a minute. Comprehensive rules for the installation of sprinkler equipments and their maintenance are contained in The National Board of Fire Underwriters' Pamphlet No. 13, entitled "Regulations for the Installation of Sprinkler Equipments."

An approved automatic sprinkler equipment, with a good water supply, is considered the most effective method of extinguishing fire. Let us look at the record to confirm this statement. Records kept over a period of 41 years, from 1897 to 1938, show that the operation of automatic sprinkler equipment in a total of 61,408 fires has been satisfactory, except in 4 per cent of these fires. About one-half of the number considered unsatisfactory was due to faulty maintenance, such as water supply shut off, sprinkler heads obstructed, and other conditions brought about by the human element. The installation of sprinkler equipments is essential for safety against fire in buildings having large areas and hazardous occupancies. Ordinarily installations protect the entire area of a building; however, many such installations are made to protect small areas housing hazardous processes and materials. The following figures give some idea of the frequency with which such installations are made. There are about 250 of these sprinkler installations in the City of Indianapolis; in the City of Chicago there are about 2,000 complete sprinkler installations, and many such installations giving partial protection.

Inasmuch as the extinguishment of the great majority of fires is dependent upon the operations of the fire department, this phase of the utilization of water will now be dwelt upon. Each member, and especially the officers, of a fire department should make a study of and become acquainted with the water distribution system of his

city. Each fire station should be supplied with a map showing the mains, hydrants, and gate valves in the system, also the valves controlling 2-inch and larger service connections entering buildings. The map should show the main to which each hydrant is connected, for in many cases a hydrant on a large main may give an ample supply, while the next hydrant may be connected to a small main which will give a deficient supply. In order that the members of the fire department may know by physical inspection the ability of hydrants on a distribution system to deliver water, the A. W. W. A. has developed an optional standard method of marking hydrants (Jour. A. W. W. A., **29:** 449 (1937)). This is based on tested flow capacity of each hydrant, wide open and flowing alone. This is as follows:

A. W. W. A. Optional Color Scheme for Hydrants

Barrels of all post hydrants to be painted *chrome yellow* for visibility. Tops and nozzle caps to be divided into three classes:

Class A: Hydrants having a flow capacity to supply 1,000 gallons a minute or more, the tops and nozzle caps to be *green*.

Class B: Hydrants having a sufficient flow to supply between 500 and 1,000 gallons a minute, tops and nozzle caps to be *orange*.

Class C: Hydrants having a flow capacity of less than 500 gallons a minute, the tops and nozzle caps to be *red*.

These colors may readily be compared with the standard traffic signals with which everyone is familiar. Green indicates the most desirable hydrant to use, and red, the least desirable. In Chicago a somewhat different plan has been adopted; all hydrants connected to mains 12 inches and larger in diameter are painted *chrome yellow*, and the hydrants on the smaller mains are painted *red*. With an intimate knowledge of the location of the hydrants and their delivery capacities, the fire department is in a position to utilize efficiently the available water supply.

It is equally incumbent on the water department to maintain the hydrants in operative condition and also to install a sufficient number of hydrants so that excessively long lines of hose will not be required. When the fire company reaches the fire grounds it is prepared to use its equipment to the best advantage, provided the officer is experienced and the members of his company are well trained. Each engine company should carry the following basic equipment:

1. A 2½-gallon chemical extinguisher or 5-gallon hand pump. These devices are capable of discharging 2½ gallons a minute through an ⅛-inch tip.

2. A booster line consisting of 150 or 200 ft. of 1-inch rubber hose having a ¼-inch shutoff nozzle which is capable of delivering water at four times the rate of the chemical fire extinguisher or hand pump, or 10 gallons a minute.

3. One or more lines of 1½-inch, cotton-jacketed, rubber-lined fire hose having a ½-inch shutoff nozzle which is capable of delivering four times the quantity delivered by the booster line, or 40 gallons a minute.

4. A 2½-inch, cotton, rubber-lined, fire hose equipped with a 1-inch or a 1⅛-inch tip. The smaller tip will deliver four times the quantity of water delivered by the 1½-inch line, or about 160 gallons a minute.

Upon reaching the fire grounds and approaching a fire an experienced fire department officer in most cases can estimate the volume of fire which is to be extinguished, and he immediately selects the suitable equipment. The major proportion of fires, roughly between 70 or 80 per cent, are extinguished with the smaller streams, either from hand chemical extinguishers, hand pumps, and booster lines, and under most circumstances where fires are in progress in buildings and have not broken through the windows or the roof, the company immediately upon its arrival makes its entrance and advances with this equipment, attempting to reach the seat of the fire; however, where there is definite indication of fire, these small-stream appliances should be backed up immediately by laying a 2½-inch hose line and charging it with water up to the building entrance.

Little attention has to be given to the problem of the proper pressure to carry on the booster line or on the 1½-inch hose lines as pressures from 40 to 50 lb. at the nozzle give satisfactory streams which have an effective reach of about 40 or 50 ft. Such streams can be developed readily where hydrant pressures are over 50 lb., or by maintaining pressures of equal amounts on the pumper discharge. Considerable bodies of fire can be handled particularly with the 1½-inch lines with the ½-inch tips. These lines and also booster lines are used to great advantage in combating fires which have involved a large portion of the roof structure of a gabled-roofed, frame building, the lines being advanced from the inside of the building to the attic space or top loft and with the stream directed so that

the major portion of the water is projected outward through the holes which have already been burned in the roof. This procedure keeps water damage at a minimum. In years gone by fire departments generally directed $1\frac{1}{8}$-inch streams from a $2\frac{1}{2}$-inch line on a burning roof from the ground, and the resultant water damage was heavy. It has been stated by a number of experienced fire chiefs that $1\frac{1}{2}$-inch lines with $\frac{1}{2}$-inch tips can control material fires in the majority of cases where it is possible for the pipeman to make the entrance without gas mask or other breathing apparatus.

Fires involving large areas filled with enormous quantities of combustible materials require heavy streams; $2\frac{1}{2}$-inch lines having $1\frac{1}{8}$- or $1\frac{1}{4}$-inch shut-off nozzles should be used for interior work of this character. In using these larger streams the fireman is confronted with the problem of developing a suitable hand line stream. Sufficient pressure must be developed at the nozzle to throw an efficient fire stream, and at the same time, too much pressure is undesirable because the reaction of the hose line handicaps the pipeman, both in directing the stream and in advancing the line. Experience shows that a nozzle pressure of about 50 lb. is most desirable for these interior streams. This pressure gives a horizontal and vertical reach of between 70 and 80 ft. It is true that such a stream throws a spray to a considerably greater distance, but a solid stream is required to produce the blanketing and quenching effects needed to extinguish the fire.

Fire Stream Hydraulics

It is only within the last decade that firemen have become so proficient in solving their fire stream hydraulic problems on the fire grounds that such streams could be developed without the "cut and try" method. This advancement in the art, to my mind, is due to the fact that in the past ten or fifteen years over 60,000 firemen throughout the country have been attending fire schools and receiving instructions in the subject of fire streams, as well as many other problems which arise in connection with their duties. A fire officer, a pump operator, and a large proportion of the firemen today know that, in developing a hand fire stream from a $2\frac{1}{2}$-inch line, a 50-pound nozzle pressure is the objective. They know that the friction loss in a hundred feet of $2\frac{1}{2}$-inch, cotton, rubber-lined hose is as follows:

4 lb. per 100 ft. for a $\frac{3}{4}$-inch nozzle,
7 lb. per 100 ft. for a $\frac{7}{8}$-inch nozzle,

10 lb. per 100 ft. for a 1-inch nozzle,
18 lb. per 100 ft. for a $1\frac{1}{8}$-inch nozzle,
25 lb. per 100 ft. for a $1\frac{1}{4}$-inch nozzle.

These figures can be kept readily in mind by association: 4 appears in $\frac{3}{4}$; 7 in $\frac{7}{8}$; 10 is associated with 1; the figure 18 appears in $1\frac{1}{8}$, and 25 in $1\frac{1}{4}$.

Let us take an example: 800 ft. of $2\frac{1}{2}$-inch hose has been laid out and connected to the pumper discharge, and a $1\frac{1}{8}$-inch tip has been placed on the shutoff nozzle. The pump operator knows the size of the tip, and has estimated the length of hose in units of 100 ft. He then multiplies 18 by 8 and obtains 144, which will be the friction loss in the line when $1\frac{1}{8}$-inch tip is delivering an efficient stream; this requires 50 lb. at the tip; therefore, the operator adds 50 to 144, and operates his pump with 194 lb. discharge pressure. If the line has been taken to the roof of a four-story building, the pump operator allows a loss for elevation of 5 lb. per story, and adds 20 lb. to the before-calculated discharge pressure, and then operates with a discharge pressure of 214 lb.

Let us take another example: It is found necessary to lay out 1,200 ft. of $2\frac{1}{2}$-inch hose to reach the fire. The commanding officer selects a 1-inch nozzle tip in this instance. The operator then multiplies 12 (the length of hose in hundreds of feet) by 10 (the friction loss in each 100 feet then supplying the 1-inch tip) and obtains 120. To this he adds 50, the pressure required at the tip to develop the stream, and operates his pump at 170 pounds discharge pressure.

Until the advent of the automobile pumping engine many cities depended upon the raising of the pressure on the water system to develop fire streams. From the foregoing examples it is clearly evident that efficient streams could not always be developed by this means because of the limitations in pressures which pumping stations could develop and which the underground piping system could withstand. The raising of pressures introduced the hazard of rupturing the mains at the time when their supply was most sorely needed, and also from the present-day viewpoint, it would be very inefficient. For instance, a steam-operated station delivering at the rate of 10,000,000 gallons a day at 50 lb. pressure would require considerable reserve boiler capacity to be kept under steam at all times to raise fire pressures even to only 75 lb. Numerous observations on systems where pressures were raised for fires show that the consumption rate increased at the rate of one per cent per pound increase in pressure.

The 10,000,000-gallon consumption rate would, therefore, increase 25 per cent, or to 12,500,000-gallon rate. The increase in pressure and increase in rate would impose an additional load on the boilers 86 per cent in excess of the normal rate, and additional steam would be required to deliver any water which might be drawn from the system by the fire department. If pressures are raised in electrically-operated stations, practically the same increase in power is required. Increases in pressure are generally made by placing centrifugal pumps in series.

Calculation of Effective Stream at Nozzle Tip

Fire streams delivered from nozzle tips having diameters greater than $1\frac{1}{4}$-inch require that they be delivered from jacks, deluge sets, wagon pipes, deck nozzles, or water towers. It is not feasible to handle such streams from hand lines because the reaction of such streams requires mechanical equipment to provide for their safe and efficient use. The reaction of a fire stream in pounds is equivalent to the pressure at the nozzle tip, multiplied by the square of the diameter of the tip, multiplied by the constant $1\frac{1}{2}$. For instance, a $1\frac{1}{2}$-inch tip develops a very efficient fire stream at 75 lb. nozzle pressure. To determine the reaction of this stream, multiply the diameter of the nozzle by the diameter of the nozzle, this product by 75, and this product in turn by $1\frac{1}{2}$; the result is 253 lb. Practically the maximum effectiveness of a 2-inch stream is obtained with 100 lb. at the tip. The reaction of this stream is obtained by multiplying 2 by 2; this product is multiplied by 100, and this product in turn by $1\frac{1}{2}$; the result is 600 lb.

The problem of efficiently and rapidly developing such master streams has been given special study during the past several years by the Chicago Fire Department. In approaching the problem, certain facts should be kept in mind. The capacity of the motor pumper is mainly dependent on the power output of the gasoline engine. A 1,000-gallon pumper is rated at 120 lb. net pressure; it, therefore, has 120,000 pound-gallon units of capacity. When delivering at higher pressures, therefore, its capacity is reduced, for when delivering at 240 lb. discharge pressure, its capacity is only 500 gal. Therefore, it is perfectly evident that hose lines of sufficient carrying capacity should be provided from the pumper to the heavy stream appliances to keep the friction loss at an economic minimum. The friction loss in 100 ft. of $2\frac{1}{2}$-inch hose, when carrying 300 gal. is

21.2 lb.; the loss in 100 ft. of 3-inch hose, when carrying the same quantity, is 8.2 lb. per 100 ft.; and in 3½-inch hose, when carrying the same quantity, it is 3.7 lb. per 100 ft. Two lines of 2½-inch hose, siamesed, give 5.9 lb. loss per 100 ft. when carrying 300 gal.

The following formula gives approximate friction loss in 2½-inch hose per 100 ft. of hose line: $2Q^2$ plus Q, where Q is the quantity in gallons divided by 100.

Inasmuch as it is not feasible to make calculations on the fire grounds, neither can it be determined in advance what supply of the several sizes of hose, i.e. 2½-, 3-, and 3½-inch, may be available for making any required layout, the Chicago Fire Department has developed a method by which satisfactory results can be obtained on the fire grounds in a minimum length of time. For instance, it is decided to place a water tower in service; the water tower carries two turret pipes, each having a 2-inch nozzle, also a 2-inch nozzle on the play pipe at the top of the 65-foot mast. The quantity of water required to produce maximum effective streams from these three tips is 3,750 gal. of water a minute. The pressure required at the base of the play pipe is 140 lb. In performing this evolution the commanding officer selected the location to fit the tower, and assigned 4 engine companies and one high-pressure hose wagon to lay the hose and to supply the tower. The tower and high-pressure wagon were located within 0.3 mile of the selected location. The engines were located, respectively, at 0.4, 0.5, 0.6, and 0.7 of a mile. The members of companies were reclining on their beds in the dormitory. The time which elapsed from the stroke of the gong until the relief valve at the base of the tower blew at 140 lb. was 3 min. and 34 sec. In all, eighteen 50-foot lengths of 2½-inch, 29 lengths of 3-inch, and 28 lengths of 3½-inch hose were laid. The discharge pressures on the pumpers when operating ranged from 150 to 200 lb.

As a result of this demonstration, general orders were issued to the department directing commanding officers of engine companies, when ordered to lay into equipment to develop master streams, to lay a sufficient number of hose lines of whatever size might be available to reduce the discharge pressure on their engines to about 160 lb. when operating on full throttle. Shortly after these orders were issued, a fire occurred on the fourth floor of a large-area building at 8 A.M. when the temperature was 10 degrees below zero. The volume of fire was such that when the first-alarm companies arrived, the commanding officer ordered the tower into service, and it de-

veloped its full capacity in exactly four minutes. This operation demonstrated very forcibly the desirability of training groups of fire companies to perform evolutions which they will be called upon to carry out on the fire grounds.

Limitations of Effective Reach of Fire Streams

In closing, it seems appropriate to touch upon a subject which has been discussed and is being discussed in firemanic circles; that is the limitations of effective reach of fire streams. It is a popular notion that effective fire streams reach farther than they do, and that a continued increase in pressure increases their effectiveness. The facts are that 100 lb. produce about the maximum effective fire stream, and the diameter of a nozzle tip has a slight influence on the reach of a stream. For instance, at 100 lb. pressure the vertical reach of a 1-inch stream is about 98 ft.; of a $1\frac{1}{2}$-inch stream, about 107 ft.; and of a 2-inch stream, about 115 ft. Now let us see what the effect is of increments in pressure. At 60 lb. a $1\frac{1}{2}$-inch stream has an effective vertical reach of 91 ft.; at 80 lb., 101 ft.; at 100 lb., 107 ft.; at 120 lb., 109 ft.; and further increases in pressure increase the effective reach in the same decreasing proportion.

The effective reach of a fire stream may be determined by the following formula: $H = \sqrt{240\,P - P^2 - 1900} - 15$, where H is height in feet and P is pressure in pounds per square inch. (Reduce 15 by 1 for each $\frac{1}{8}$ in. above $\frac{3}{4}$-inch nozzle if 50 lb. or under, and by 2 for over 50 lb.)

Box's Formula gives less heights: h equals $\frac{H^2}{d} \times 0.0125$; h is the head in feet which must be subtracted from the theoretical head to give the maximum height of the jet; d is the diameter in eighths of an inch, and H is the pressure head on the nozzle, in feet.

The results obtained by these formulas are sufficiently accurate as the effective reach of a fire stream is materially influenced by the wind, and wind velocities of less than 5 miles an hour occur only infrequently and for periods of short time.

In general, it may be stated that hydraulic problems in connection with fire streams cannot be worked out with a laboratory degree of accuracy because of the many variables encountered in actual service.

Consideration of Distribution System Design For Adequate Fire Protection

By George Tatnall

IN A paper published in the December, 1938, issue of the Journal of the American Water Works Association, this writer presented a discussion of fire flow requirements in various districts commonly found in any city. No attempt will be made to repeat the details of this paper but certain of the figures applying to a hypothetical city of about 28,000 population will be summarized and an analysis made of a typical distribution system to see whether or not it will meet these requirements. Unfortunately a typical system will not. We shall attempt to discover why and to find out the most feasible way of overcoming the deficiencies.

This theoretical city will require a fire flow of 5,000 gallons a minute in the principal mercantile district. There will be industries in varying amounts; let us assume that these are largely concentrated in a two- or three-story building somewhat centrally located and covering a block or more and that this will require 4,500 gallons a minute. In a city of this size there is not likely to be any extensive minor mercantile district but we may assume one or two hotels and some grouping of stores down by the railroad station, requiring a fire flow of 3,500 gallons a minute. There will be a number of school buildings scattered over the city; probably a large high school of modern construction, requiring about 4,000 gallons and others smaller in size, some of which will be older and of ordinary wood joisted construction. Such buildings will also require about 4,000 gallons while the more modern smaller school buildings will be adequately protected with 3,000 to 3,500 gallons. There will also be churches of small to moderately large size for which we will assume requirements of from 2,500 to 3,500 gallons. The central residential districts will be,

A paper presented on April 28, 1939 at the Ohio Section Meeting at Dayton, Ohio, by George Tatnall, Engineer, The National Board of Fire Underwriters, Chicago, Ill.

in general, solidly built, usually with an older type of large house. In part these will be somewhat run down and some will be occupied as tea rooms, rooming houses or other semi-mercantile occupancies. For some of these blocks 2,000 gallons may be sufficient but in many 2,500 gallons and in a few 3,000 gallons will be necessary. The more outlying residential sections will generally consist of detached frame dwellings; the degree of congestion, both as to the size of buildings and spacing on lots, will vary considerably. The older sections will probably have wooden shingle roof coverings predominating. Some sections will have only a moderate part of the lots built up. There probably will also be one section, usually on a hill, with large modern houses spaced widely on large lots. The requirement for fire flow in these residential districts will vary from a usual minimum of 1,000 gallons to about 2,500 gallons, with the great majority needing 2,000 gallons.

Fortunately the condition we will assume for supply to this city is not as common as it used to be but there still are such systems and they serve the purpose well for an example. Suppose a single 16-inch feeder extending about 2,500 ft. from the pumping station to the principal mercantile district with only an inconsequential amount of parallel gridiron. A 12-inch main continues to a 1,000,000-gallon elevated tank which gives a pressure of about 55 lb. in the district. Assuming that the tank storage is equally distributed over a 10-hour period these mains will be adequate to deliver the necessary fire flow to the district at 20 lb. residual pressure under a maximum consumption rate of 4,000,000 gal. even if all this consumption is assumed to flow into the district. Thus the part of the district through which the 16-inch main passes is shown to be well protected by a calculation very much on the conservative side. Often we will find that the district has grown and shifted away from the original main street; this new portion is just as deserving of full protection as the old. Refining our calculations a bit and assuming that one-fourth of the consumption drops off the feeder rapidly in the northern part of town we find a friction loss in the feeder of about 60 feet. Dropping from 55 to 20 lb. we have only about 80 ft. of permissible loss. To center our 5,000-gallon fire flow two blocks, or 800 ft., from the feeder will require a gridiron equivalent to a 15.2-inch pipe. To supply this the instillation of at least a 12-inch branch and perhaps a 12-inch loop will be necessary depending on the existing gridiron. We will defer decision on this point for the present.

We can now turn our attention to the other centers of high demand. We have assumed that the large manufacturing plant is somewhat centrally located; it is then a potential center from which a conflagration might spread to the remainder of the city. In such a case we must consider it our special duty to provide full protection; if the plant did not expose other property or was in an extreme outlying section we might not feel so vitally concerned. Consider the unfavorable condition of location of this plant beyond the end of the 16-inch supply line and away from anything larger than an 8-inch sub-feeder. If the distance is 2,500 feet farther and we should continue our 16-inch main all that distance we would have a friction loss of 87.5 ft. just for the necessary fire flow without considering any consumption. This is in excess of the 80-foot loss permissible and we are forced to the conclusion that something radical must be done to our system.

Single Feeder is Source of Trouble

Some further thought makes it apparent that the trouble is largely centered in the excessive initial friction loss in the single feeder. We are also conscious of the factor of unreliability involved in being almost entirely dependent on a single feeder for supply. We then begin to plan a parallel feeder which will certainly be not less than 12-inch and more probably 16- or even 20-inch. Our first feeder was probably laid as directly as possible to the business district; this second line may be made to serve a dual purpose by detouring to pass by some of the others centers of high demand, say, perhaps the high school and several of the churches. The installation of this line is vital to the further planning of our system; the increased pressure available for loss in branches will allow us to be certain of correcting the weak spot in the principal mercantile district with the one 12-inch branch line (1).* For the industrial plant we will require the equivalent of more than a 15-inch pipe, probably a new 12-inch to the plant with the existing 8-inch will not be quite sufficient and we will need to loop the 12-inch line (2).

Now consider the railroad station and surrounding minor mercantiles; these may be rather isolated across the tracks and, very likely, most of the minor distributors do not continue across so that supply may be largely dependent on one or two 8-inch lines. It is obvious that even though our primary friction loss is cut down to a small

*See figures in parenthesis on fig. 1.

amount, the distance from this main feeder is increasing and even without considering any consumption the 3,500-gallon fire flow requirement is going to run up excessive losses in such secondary feeders. This requirement is going to necessitate a grid equivalent to about a 14-inch pipe and we will need to plan on a 12-inch feeder direct to this district (3).

Let us consider that we have been able to detour our second principal feeder past the new high school and the old building across the street now used for grade school purposes. If these should be on the other side of the city another calculation would be necessary to see whether a 12-inch branch or a 12-inch loop is needed.

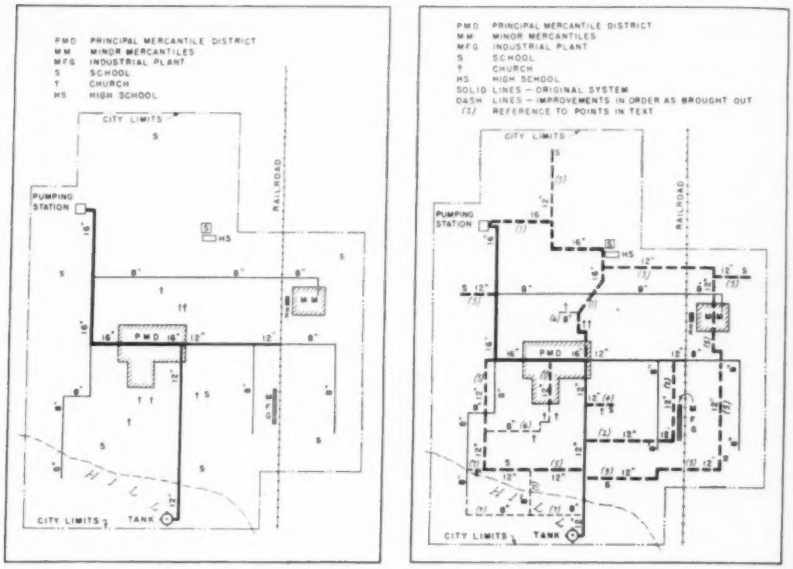


FIG. 1. A Hypothetical System. LEFT: Before improvements; RIGHT: After improvements.

The next concentration of demand may very likely be a large church with school and other accessory buildings grouped adjacent. This group will probably require 4,000 gallons a minute but will be rather centrally located. The exact distances and the existing gridiron involved will again determine whether or not a 12-inch line to this hazard will have to be looped back to another feeder (4).

Other schools will often be more remotely located and, although the requirement is less, it will generally be found necessary to serve them from 12-inch loops passing within a block or two. These loops

may permissibly be of considerable length and in some cases 10-inch loops might theoretically serve; we shall see later that other considerations make the use of this size of pipe undesirable (5). Most of the remaining churches of any size will be quite centrally located and can probably be satisfactorily protected by judicious 8-inch reinforcements to the gridiron (6).

The older residential districts will very likely be served by minor distributors which include a considerable proportion of 4-inch pipe. It can be demonstrated by calculation and is also a well accepted fact that even a 2,000-gallon requirement cannot be satisfactorily obtained from such a grid and correction by the provision of 8-inch lines is particularly important in these older and more congested sections. The gridiron existing in any such city is a factor that may vary considerably both because of previous policies as to extensions to the system and the prevailing shape of blocks. Again it is fairly obvious that 6-inch lines unsupported for lengths of much over 800 ft. will give an entirely unsatisfactory supply for one fire engine from the central hydrant if any amounts are taken off from the next hydrant either way. This will be true even if there are 12-inch or larger feeders spaced about every half mile so that lines may be considered well fed from each end, and, of course, the condition is aggravated if there is a higher loss in feeders because of the use of 10-inch pipe or if the district lies toward the outskirts and there is no outer 12-inch feeder installed. Some cross-connection is essential; whether these lines will be 6-inch every block or 8-inch every other block will be determined by the exact available friction loss conditions prevailing and whether or not blocks are of such shape that some consumers may be picked up in each block by the cross-connecting 6-inch line.

Our hypothetical city has one more district to which we should give further attention; the high-value residence section on high ground. So far we have assumed our city to be flat and have neglected any factor for varying elevation. In most practical cases this factor will have to be considered to a greater or lesser extent. In this case our normal static pressure of 55 lb. may be reduced to 40 lb. or less by elevation alone and the amount of available pressure left for the gridiron after considering a loss of 30 ft. in the feeders will be only 16 ft. instead of the 50 ft. on lower ground. In designing or reinforcing this part of the system the amount of 8-inch pipe must be materially increased and the gridiron be made correspondingly closer (7).

We have considered the method of procedure involved in analyzing a theoretical but rather typical distribution system as to its ability to deliver the various necessary fire flows at different points. This procedure can be applied to any system in a similar manner, using the existing layout of feeders and the prevailing pressures. For practical purposes calculations can be made on the feeders with only an assumption of the parallel flow in adjacent gridiron. On certain feeders it will be evident that some or all of the consumption must be included but on others this factor may be largely neglected. No great accuracy is needed in estimating the division of consumption into districts and this may be done by taking substantial amounts off the feeders at one point instead of gradually as is the actual case. This latitude in calculations is allowable because the hourly variations in consumption above or below the maximum day's rate assumed will compensate for numerous errors. Also the necessity for confining actual installations to commercial pipe sizes usually gives considerable leeway. Calculations may be made on the gridiron of minor distributors but a series of actual fire flow tests will probably give as satisfactory results with less labor.

Reinforcements Correct Several Weaknesses

Reinforcements, where supply is found to be unsatisfactory, should be designed, insofar as possible, to serve several purposes. The primary one will be, of course, to correct a definite weakness, but we must keep in mind the secondary ones of improving reliability and of picking up some other weak point en route. Calculations are necessary for determining the size of arterial reinforcements but in making additions to the gridiron, experience or comparison of the results of fire flow tests in similar districts will be found the most feasible means of determination.

The principal point to keep in mind in designing reinforcements to a distribution system is a careful consideration of any and all centers of high fire flow demand, particularly any which have been previously neglected. Where deficiencies are found the work toward correcting them must be judiciously balanced between cutting the initial friction loss in feeders or strengthening the gridiron. Factors of possible future growth or shifts of population must also be taken into consideration. Naturally in any existing system it is not probable that all deficiencies can be corrected immediately but, if the weaknesses are all studied and the necessary extensions for correction decided

upon and outlined on a map, you have made a good start. It will then be possible to lay mains of proper size when any of the streets involved are paved and to set up a program for the laying of two blocks, or two miles, of such lines each year. It is not expecting too much to hope to attain full fire flow requirements at from 80 to 90 per cent of the street intersections in the city. If you have made your studies and calculations, set up your extension plan and made a start upon it, you are to be complimented on your realization of the needs for adequate fire protection.

Discussion by *Frank C. Tolles*.* Mr. Tatnall, in his paper, has erected an hypothetical city, but that does not affect the validity of his diagnosis as will be borne out by all who have had to check over an old system. His emphasis upon weakness in the main feeder is particularly true to life, and likewise the reference to 4-inch lines in the distribution system. The principles of water supply and distribution for fire protection are clear and are readily applied although the process may be tedious.

While poor engineering or none at all may be responsible for some defects, most of the difficulties with fire protection measures have been financial and equally obviously, these difficulties arise from the shifting relationship between supply for fire protection and supply for domestic or industrial usage—a relationship that changes rapidly with the size of the community.

Take, for example, a supply of 500 g.p.m. From the standpoint of fire protection, that is so small as scarcely to justify recognition, but for all other purposes it would be ample for a very sizable village. Put differently, a community that can get along comfortably on a consumption of 500 g.p.m. needs perhaps four times that rate of supply if its fire protection approaches usual requirements. It is this situation that is responsible for the fact that, in the smaller communities, some 75 per cent of water works expenditures are for fire protection.

Revert, if you will to Mr. Tatnall's City of Nemo. It has a population of 28,000, and, if it follows characteristics usual in Ohio cities, it has invested a capital amount of about $700,000 in water works plant. The distribution system includes some 80 miles of piping, but more than 60 miles of this is in 4-inch or 6-inch sizes that are of little help for fire protection. Despite this inadequacy, the system

* Consulting Engineer, Cleveland, Ohio.

includes nearly 500 hydrants, some storage, nearly three miles of mains 12-inch or larger and excess pumping capacity. All in all, it is probable that half of the total cost, a matter of some $350,000, could be attributed to protection service, and exclusive of any costs for debt service. The betterments that are suggested in the paper would cost at least an additional $50,000.

The usual engineering approach to problems of planning involves a balancing of debits and credits in some effort to determine whether the improvement is justified. This would be a proper procedure in adjudging the needs of fire protection, but unfortunately few of us outside of the insurance field are equipped even to estimate with any assurance. Then, too, we must recognize that water supply and water distribution are minority factors in the grading schedule.

It is beyond the scope of the author's paper to present any economic justification for water supply expenditures on account of fire protection. The mode of analysis in this is clear enough but to obtain the basic material is so difficult that I am hoping that someone who is well versed in the application of the grading scale will lead us to some short method or to generalized figures that will offer at least presumptive indication of the validity of water works improvements in their influence upon community costs for fire insurance.

Bypassing this phase of the question, the problem of supply and distribution for fire protection in the small communities which provide the bulk of this kind of work, is largely one of stretching the dollar. Within the elastic limit of that dollar, there are certain items such as reserve pumps, duplicate feeders, and storage that probably yield a maximum of return for the investment. This is particularly true of storage which, if adequate in capacity and suitably located, will not only furnish a positive reserve, but will multiply the capacity and effect of the distribution system.

But even after taking advantage of all the opportunities that offer the particular location, it is an unusual case where there are sufficient funds for building (in the small community) a system that will be in reasonable accord with Fire Underwriters' requirements.

To meet this situation calls for nicety of judgment as to where the money can be used to the maximum advantage. Such judgment might indeed prompt construction that is effective in a degree that is less than for some alternative construction, and this on the basis of the ease or the difficulty of obtaining later grants for expansion of the system.

It is impracticable to generalize in this, but the point of this discussion is that all designs for supply and distribution should be made to meet full requirements, and so shown in the record. With such a complete design available for later expansion of the system, it then becomes possible to cut and to omit to the point of meeting funds, but to do so from the knowledge of what will be necessary ultimately.

The objection to setting up a complete and final design is that of inflexibility—the lack of conformance to growth and development yet unseen. But this danger is guarded against in a proper design, for such contingencies are recognized and opportunity given for the insertion of remedies as such prove necessary. Moreover, and if the change is radical or the growth considerable, it is often permissible and economic to cast aside the old and design anew.

Perforce this discussion has been a bit cryptic, but the essential suggestions are these: In the design of fire protection facilities for the small plant where funds are insufficient for full and adequate performance, it is none the less incumbent upon the engineer to place in the record a fully designed system. Building so much of this as is feasible, and providing further for accumulating reserves by hydrant rentals and by an adequate rate structure, the designer has given the community the best they can afford and he has put them in the way of piecemeal additions that will be directed to the desired ultimate. This is honest engineering.

Discussion by *E. E. Smith.* * Mr. Tatnall's interesting paper hypothecates conditions, deficiencies, and suggests remedies for fire protection for a city of 28,000 population. Inasmuch as Mr. Tatnall creates his situations, the corrections are mentally existing at the same time. Such an inclusive paper scarcely permits discussion of its subject matter, but suggests the application of hypotheses to facts.

The most natural application of Mr. Tatnall's paper by a water department would be personal and local. Comparisons may be made and conclusions drawn for correction of actual deficiencies just as suggested by Mr. Tatnall for his hypothetical typical city. For the city of Lima to be considered, it will be noted that the fire flows in the principal mercantile district should be 6,000 g.p.m. instead of 5,000. We find the Underwriter's Report (the last available, of 1931) indicating an average flow of 7,600 g.p.m. Minor mercantile district

* General Superintendent of Water & Sewage Treatment, Lima, Ohio.

flow should be 3,500 and we find 3,400. Industrial requirements should average 4,100, but actual flows are 3,400. Residential flows have been set at 2,200 and but 1,900 are found.

Summarizing the deficiencies of the city of Lima water distribution system (inasmuch as the general layout of feeder mains and branches are admittedly good) as suggested by Mr. Tatnall's paper, it is noted that Lima's principal and minor mercantile districts are adequately served, while the industrial and residential districts are not. This may be explained by the feeder layout—one 20-inch feeder going directly through the principal mercantile district to one residential district, while the other 20-inch feeder is at right angles to the first, going to the industrial district and cross-gridded to the first feeder through the minor mercantile district.

The assumption in Mr. Tatnall's paper that his hypothetical city would have one 1,000,000-gallon elevated tank at the end of the main feeder is the remarkable omission of the Lima situation. A 1,000,000 gallon elevated tank at the ends of the 20-inch feeders at Lima would not only correct the fire flows in the industrial and residential district, but in large measure compensate for present dependence on maximum filter rates.

Regulations for Water Main Installations

By Harvey T. Green

EXTENSIONS to the distribution system of the Bureau of Water Supply of Baltimore are made under a number of methods. This condition arises from the fact that the Baltimore water system supplies not only Baltimore City but portions of Baltimore, Anne Arundel, and Howard Counties, which are contiguous to the city. Although it is proposed in this paper to discuss in detail only those regulations applying inside the city limits, it may be pertinent to note briefly the method of extending mains in the counties.

Since the creation of the Baltimore County Metropolitan District in 1924, main extensions in that area are made by the County Commissioners under an assessment plan whereby the applicant is required to advance the estimated cost of the installation, the deposit being refunded in pro rata amounts as consumers are connected to the extension and thereby being subjected to the front foot assessment of 15 cents per year.

The Dundalk area of Baltimore County, although lying within the Metropolitan District, is not a part of the District insofar as the extension of water mains is concerned. This area, in addition to an adjacent area inside the city limits, was formerly served by a private water company which was subsequently purchased by the city. Main extensions in the Dundalk area are made under a special agreement with the developer which provides for a deposit of the estimated cost of the extension with a credit or refund allowance of $75 for each new consumer connected before the expiration of ten years from the date of the deposit, these refunds being payable in five annual installments.

In Anne Arundel County the method is similar to that for Dundalk, the chief differences being that no credit allowances are made and

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the applicant's refund installments total $100 for each dwelling or other consumer connected to the main extension within three years. Extensions are also made by the County Commissioners subject to the approval of the Bureau of Water Supply.

Under an agreement with the County Commissioners of Howard County, the Commissioners may extend mains in that County upon approval of the Bureau of Water Supply. Mains installed by the Commissioners of both Howard County and Anne Arundel County are, upon completion, deeded to Baltimore City and are financed by bond issues, special taxes being levied upon the districts benefited.

The foregoing methods are in contrast to the requirements for main extensions inside the corporate limits of Baltimore City which provide for a deposit of $1.50 per linear foot of 6-inch main with a credit or refund allowance of $100 for each building supplied from the extension or for each $20 annual revenue from such building. Prior to the annexation of 1918, a large part of the territory acquired by the city was supplied by private water companies, the largest of these being the Baltimore County Water and Electric Company. Most of these private water companies were purchased by the city in 1921 and incorporated in the distribution system of the Bureau of Water Supply shortly thereafter. At this time the main extension regulations of the Baltimore County Water and Electric Company were substantially adopted in the formulation, in 1923, of new regulations for extensions throughout the city.

The private water company had used a more or less flexible guarantee method based upon the price of cast-iron pipe. Under a guarantee plan, the applicant is required to guarantee that the revenue to be received from a given main extension will be sufficient to justify its installation, this guarantee usually being in the nature of an advance deposit which is subject to refund, at a predetermined rate, for new consumers.

Although the deposit required by the Baltimore County Water and Electric Company varied between $1.00 and $1.50 per linear foot of extension, paralleling the price of cast-iron pipe, the latter price attained a high level which it held for some time and consequently most extensions made just prior to 1923 were on the basis of a deposit of $1.50 per linear foot, with the result that the Baltimore City regulations of 1923 fixed the deposit requirement at that figure. Since then the $1.50 per foot deposit has been the essential element in

Baltimore's water main extension regulations although, when the regulations were revised, this charge was limited to 6-inch mains.

In order to analyze the rate and its corresponding allowance of $66\frac{2}{3}$ ft. of main per consumer, a study was made of all mains installed during a seven-year period from 1929 to 1936 to supply new domestic consumers. A total of 264 such extensions was examined as to

TABLE 1

Results of Main Extension Study

Number of Extensions		264
Length of Main		111,556 ft.
2-inch main	124 ft.	
4-inch main	483 ft.	
6-inch main	78,688 ft.	
8-inch main	15,701 ft.	
10-inch main	10,892 ft.	
12-inch main	5,668 ft.	
Cost of extensions		$305,089.34
Number of New Consumers		2,426
Metered Rate	1820	
Flat Rate	606	
Revenue		$37,486.70
Metered Rate	$27,695.20	
Flat Rate	9,791.50	
Consumption		21,014,000 cu.ft.
Metered Rate	13,742,000 cu.ft.	
Flat Rate (est.)	7,272,000 cu.ft.	
Average Length of Extension		423 ft.
Average Cost of Extension		$1,155.64
Average Consumers per Extension		9
Average Main per Consumer		46 ft.
Average Revenue (Total)		$15.45
Average Revenue (Meter)		$15.22
Average Revenue (Flat)		$16.16
Average Consumption (Total)		8,662 cu.ft.
Average Consumption (Meter)		7,551 cu.ft.
Average Consumption (Flat-estimated)		12,000 cu.ft.

length and size of pipe installed, cost of the work, number of consumers, amount of revenue in 1938 and water consumption. The results are given in table 1.

Of course the unmetered consumption had to be estimated and the estimate of 12,000 cu.ft. approximates that determined by a survey made in 1932 for the Advisory Engineers on Water Supply and

appearing in their report. It will be seen that while the greater portion of the main is 6-inch, a considerable amount of 8-, 10-, and 12-inch main was installed. The 124 ft. of 2-inch main was a temporary installation but the applicant was charged for it.

It is probably axiomatic that the revenue from main extensions to supply new consumers should be sufficient to cover the annual costs so the next step in the study was to calculate the annual charges applicable to these extensions.

A fixed charge of 6½ per cent, based on present debt service on water loans, was used in determining the interest and sinking fund requirements of the capital investment. In allocating the operating costs chargeable to the extensions, the operating cost of $37.90 per million gallons for the entire system for the year 1938 was used.

One more factor enters into the determination of the annual charge when consideration is given to the fact that continual additions to the distribution system will eventually require increased collecting, filtration and pumping facilities, etc. In other words, each extension should bear its share of the cost of constructing the present system, in proportion to its capacity. The valuation of the entire water works of Baltimore at the end of 1938 was $86,649,559.63 including 8,378,593 ft. of main valued at $35,396,292.45, and the remainder of the system valued at $51,253,267.18. By rating the various sized mains according to their relative carrying capacities, the equivalent length of 6-inch main was found to be 63,762,832 ft. Dividing the $51,253,267.18 by 63,762,832 ft. resulted in a unit plant value of $0.80 required for each foot of 6-inch main. As the main extensions investigated, aggregating 111,556 ft. of several sizes, had an equivalent length of 182,073 ft. of 6-inch main, the value of that portion of the plant held in reserve which must now be utilized because of the increase in the distribution system, is 182,073 × $0.80 or $145,658.40. At 6½ per cent, the annual fixed charges on this sum are $9,467.80.

A résumé of the determination of the annual cost of the extensions studied is as follows:

Total Valuation of System—1938	$86,649,559.63
Mains Valuation	35,396,292.45
Valuation of Remainder of System	$51,253,267.18
Mains in Service—1938	8,378,593 ft.
Equivalent 6-inch Main	63,762,832 ft.

$51,253,267.18 ÷ 63,762,832 = $0.80 per ft. of 6-inch main

Length of Main Extensions Examined	111,556 ft.
Cost of Main Extensions Examined	$305,089.34
Equivalent 6-inch Main	182,073 ft.

$$182{,}073 \times \$0.80 = \$145{,}658.40$$

Consumption	21,014,000 cu.ft.
Operating and Maintenance Costs—1938	$37.90 per million gallons

Annual Charges Applicable to Extensions

1. Interest and Sinking Fund on Mains Installed	$19,830.81
2. Operating and Maintenance Costs	5,974.02
3. Interest and Sinking Fund on Additional Plant Used	9,467.80
Total Annual Charges	$35,272.63
Annual Revenue	37,486.70

The annual revenue from the extensions considered is now $37,486.70 and will increase as the area supplied has not been fully developed. From the foregoing it is apparent that, as the annual revenue exceeds the annual costs, the requirements for main extensions in Baltimore are sufficient.

Upon further investigation it will be seen that the annual cost per foot is $35,272.63 ÷ 111,556 or $0.316. By dividing $15.45, the average annual revenue per consumer, by $0.316, an allowance of 49 ft. of extension for each consumer is obtained. This allowance is less than $66\frac{2}{3}$ ft. provided for in the regulations of the Bureau. However, the 264 extensions studied were made in accordance with the regulations and already have an average of one consumer for every 46 ft. of main. Furthermore, the normal expectancy of real estate development in the area served by these extensions will reduce the average length of main per consumer. It is evident, therefore, that the allowance for each consumer, as provided in the regulations, is not excessive.

Thus far the discussion has been confined to the extension of 6-inch mains for domestic consumers. While larger sizes were included in the extensions examined, their sizes were determined in accordance with the design of the distribution system and not according to the individual needs of the consumers. Somewhat infrequently application is made for the extension of a main larger than 6-inch. Under the rules of the Bureau of Water Supply, a service pipe must be at least one size smaller than the main from which it is supplied. Hence applications for main extensions larger than 6-inch are made only when the applicant requires a service pipe larger than 4-inch. In

such cases the applicant must deposit the estimated cost of the extension, and refunds of $100 for each $20 average annual revenue are allowed.

When a water main is installed to replace an existing main, the diameter of which existing main is equal to, or less than, the diameter of the water supply service applied for by the applicant, refunds for additional consumers are allowed only in cases where the diameter of additional water supply service is greater than the diameter of the replaced main, but less than the diameter of the new main applied for. For example, the applicant for an 8-inch service to be installed in a street where there is an existing 6-inch main, must apply for the extension of a 10-inch main to replace the existing main, and after the replacement has been made, no refund for an additional consumer subsequently connected to the new 10-inch main will be allowed unless the water supply service pipe is either 6 inches or 8 inches in diameter.

Before concluding this paper, it might be of interest to note several minor, but none the less important, provisions of the main extension regulations of Baltimore.

Before any water main is extended, the grade, width and alignment of the highway, including footways, must be officially established at the expense of the applicant.

The applicant must grade the street to within 12 in. of the established grade or make advance payment of the estimated additional cost of the extension due to surplus excavation, unusual construction, and/or excess fill, such payment not to be refunded.

In a private street the applicant assumes all responsibility for the condition of the roadbed and footway, excepting those areas actually excavated by the city.

Where necessary, the applicant is required to execute, and have recorded at his expense, a deed of easement for the installation and maintenance of the water main and appurtenances.

The results of this study may be summed up in the statement that the regulations of the Bureau of Water Supply of Baltimore are reasonable in that they limit the extension of mains into undeveloped territory and at the same time they encourage progressive real estate development.

Maintaining Proper Charge for Private Fire Protection

By D. D. Gross

BEFORE private fire protection can be provided by a municipal water works large sums of money must have been expended in providing the water plant required to give the fire service. These costs must be paid by some one. If the people directly benefited do not pay them some one else must do so. When a property owner installs a sprinkler system, the popular type of private fire service, it is because he desires or needs something better than is supplied at public cost. He may even be required by law or city regulations to install a sprinkler service because of the hazard created by his own business.

The fact that sprinkler service charges are not uniform through the country is the cause of a great deal of discussion on this subject. Perhaps property owners in one city compare their costs with those charged in other cities and raise objections if they find that their schedule is higher. We often hear the desire expressed for more uniform rates.

It is not possible with justice to all customers to make sprinkler rates uniform so long as there are so many different ways of financing the water plants. True, in general, the water plant is financed by the sale of water plus what may be receivable for fire protection service; but in many cities there are other sources of revenue; the abutting property is assessed when water mains are extended; bond issues for new improvements are financed by tax money, or some other method is used to raise funds when additional money is needed to carry on the construction or operation of the water plant. These different plans may be fixed by law or usage in such a way that they cannot be changed.

A paper presented on June 12, 1939 at the Atlantic City Convention by D. D. Gross, Chief Engineer, Board of Water Commissioners, Denver, Colorado.

To simplify the problem we will consider the case of the plant that must pay its own way. It may be either publicly or privately owned. In either event an effort should be made to collect a fair return for all the services that the plant performs. In Denver we estimate that the cost of the portion of the plant required for fire protection is about 15 per cent of the total investment, and the cost of operation due to fire protection service is 2 per cent of the total operating costs. In small cities the per cent will be greatly increased and in larger cities the per cent will perhaps be decreased. The Denver Water Department does not receive payments for fire protection service commensurate with the cost. Most water departments do not receive adequate payment for fire protection service. That is, the user of water for domestic purposes is paying more than his proper proportion of the charges. In Denver the greatest demand for fire protection service is from the congested value district, but the greatest production of revenue is from the residential district. Whereas fire protection service of all kinds should pay about 11 per cent of the costs, it really pays less than 5 per cent. Yet many of the owners of sprinkler systems think that they are paying too much for the service. The dealers in sprinkler plants and the insurance men are more or less sure that sprinkler rates are too high and that they should be eliminated altogether.

Over periods of from two to five years a determined effort, usually sponsored through the Chamber of Commerce, is made to have the charges eliminated. Information obtained, usually from some national fire association, is used in presenting the case before the Board of Water Commissioners when they are petitioned to eliminate the readiness to serve charge for sprinkler service.

Petitioners, in asking for an elimination of automatic sprinkler readiness to serve charges, usually recite the high cost for installing the sprinkler service, although they think that the reduction in insurance premiums should not be taken into consideration in fixing charges for a sprinkler service. They contend that no larger mains and no higher pressures are required and that the water department is placed to no greater expense by the reason of the sprinkler system. They claim that the owner of the sprinkler system has merely brought into his building the fire protection service which his neighbor receives from the fire hydrants. They claim that the owner of a sprinkler system should not be called upon to pay an additional charge by reason of a special connection to the city water mains,

contending that he is performing a public service in that he has reduced the fire hazard in his own building; that he is benefiting not only his own property but, indirectly, his neighbor's property. They claim that in ninety cases out of a hundred the sprinkler system will extinguish a fire before it gains headway and by so doing will use less water than would be required if the fire were put out by the fire department.

In Denver the Board of Water Commissioners is required to pay all the costs of whatsoever nature connected with the water department from the revenues received from the plant operations. It is an expensive proposition to secure an adequate water supply for a large city, and this is especially true in the arid west. In the Denver water plant there is invested some $41,000,000. We consider 15 per cent of the value of the plant chargeable to fire protection service and that 2 per cent of the operation costs are also chargeable to fire protection costs. These two items total in round numbers $260,000 per year. The department receives approximately $104,000 per year from hydrant rentals from the tax collected funds of Denver and suburbs supplied, and $17,000 from readiness to serve charges on automatic sprinkler systems. That is, the revenue received from fire service should be $139,000 more per year to pay costs. The City Charter of Denver prevents any increase being made in the charge for hydrant rental, which is on the basis of so much per hydrant ($22.50 per year) for each hydrant installed. Considering these facts it does not appear that the Board of Water Commissioners has received payment for fire protection service that would render it possible to eliminate the readiness to serve charge on automatic sprinkler connections.

There is a further contention that the water plant pays no tax and that some allowance should be made due to this fact. However, the water department does supply the city with large quantities of water for irrigating the parks, for street sprinkling, sewer flushing, and similar uses. Part of this water is sold at reduced costs but for the major portion no payment is made. If the city paid the actual cost of water used for all of the above purposes the payment would balance a fair tax value on the portion of the water plant within the city of Denver.

In Denver the water pressure is sufficient in the districts where most of the automatic sprinkler systems are located to supply practically all the sprinkler services without private pumping plants. At one

time a plan of operation was adopted that gave a reduced pressure at times in the business district. This pressure could be promptly increased in case of fire and no complaint was received in regard to fire hydrant service but complaints were received on account of the automatic sprinkler services. We have found that pressure requirements for automatic sprinkler services are more exacting than the demands for fire hydrants. The automatic sprinkler requires only small quantities of water in putting out most fires, but 10 per cent of the time the assistance of the public fire protection system is required. Under these conditions the sprinkler demand for water is in addition to the demand for fire hydrants, plus requirements for domestic and other uses. The automatic sprinkler requires only small quantities of water in most cases of fire but the size of the connection fixes the possible demand on the city water mains. In case of a serious fire in a building provided with an automatic sprinkler system, there is danger that the building will collapse and break the sprinkler system piping and thus cause an excessive drain and waste of water from the city mains. These facts lead to the conclusion that automatic sprinkler service is more expensive than fire hydrant service.

In Denver the rental on public fire hydrants should not be less than $50.00 per year. The annual readiness to serve charge on the ordinary 6-inch meter is $529.80, hence a fair charge for a 6-inch automatic sprinkler service should be somewhere between $50.00 and $529.80 per year.

We know that automatic sprinkler installations reduce the chances of serious fires and hence are desirable. The fire insurance companies also recognize the same facts and reduce the insurance rates, but they do not eliminate them altogether. They must have money to pay expenses. The city water department also needs money to pay expenses and it receives no direct advantage from automatic sprinkler systems unless it does make a charge. Most city mains will accommodate more taps for domestic use without installing a new main, but the builder of a new house does not expect to get free water.

Automatic sprinkler systems are of benefit to the adjacent buildings. That is the reason that they are sometimes required in buildings where unusual fire risks exist. City laws also require the installation and use of sanitary provisions requiring water, and when they are used they also benefit the owner or tenants of adjacent property in that they protect health. Water for that purpose is not given away

free. Most water departments supply water for use in irrigating lawns and shrubs. In some cities this landscaping cannot be maintained without it. Improvements of this kind enhance the value of neighboring property, but water for this purpose is not given away free.

Some automatic sprinkler systems save their owners more in insurance premiums than all costs involved and a very large per cent save more in premiums than the cost of the water service. In Denver the total revenue received from automatic sprinkler connections is $16,740 per annum. The annual saving in insurance premiums made possible by the automatic sprinkler systems is $83,804.

Numerous decisions rendered by public utilities can be cited as proof that a charge for sprinkler service is justified.

Recently the Board of Water Commissioners of Denver has been petitioned for elimination of the automatic sprinkler service charge. One of the strongest arguments advanced by the petitioners was the statement that in some cities no charge is made and in many others only a nominal charge.

The Denver Board of Water Commissioners, after hearing the petition, has ruled to retain the present charge, which is $120 per year for a 6-inch connection, and the charge on other sizes is in proportion. No doubt many of the cities in the country are overlooking a source of justified revenue and in so doing are embarrassing those cities who are endeavoring to pay the cost of water plant operation by a just and fair charge to all consumers.

Discussion by *R. H. Ellis.* * I hesitate somewhat to enter the discussion of a controversial subject which, perhaps, has too frequently been viewed with prejudice. I feel, however, especially privileged to talk on this subject as for a considerable number of years I was connected principally with water works management and engineering whereas my connections recently have been with insurance interests.

It is not my intention to dwell on the contentions of insurance interests, nor do I intend to discuss this subject in any great detail. I do, however, desire to have you view this subject with me from a totally unprejudiced angle in order that I may leave with you a thought that has frequently been neglected when considering this

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subject. I should like you to consider with me the development of a theoretical community such as an economics professor, under whom I once studied, created for his class. For the purpose of this discussion let us assume that 500 or 1,000 families, each consisting of the same number of heads and each endowed with the same amount of wealth, establish a new community—Utopia—where each family erects a home of similar value to those of his neighbors. As these people whom we are now considering are familiar with modern conveniences, they desire and each contribute alike to, the installation of a water system for the supply of water both for domestic and for fire use.

The problems initially connected with such a system are indeed simple. As each family consists of the same number of people it would be reasonable to assume that their domestic demands on the system would be alike, and since their properties are all of like value the benefits afforded by way of fire protection would also be alike. Therefore, the total cost of operating such a system in Utopia would be equally shared by all householders.

In the course of time it would be reasonable to assume that, in this theoretical community, those endowed with the greatest sagacity, shrewdness and wisdom would gradually accumulate somewhat more wealth than their neighbors. In order to devote more time to those pursuits which prove more pleasing to them, these more prosperous individuals might engage the services of some of their neighbors, and in order to accommodate their help and possibly to enable them to entertain more, would enlarge their original homes.

Immediately the original scheme, under which the maintenance and operation of the community owned utility was supported by like contribution from all householders, falls down as there are no longer equal domestic demands, and the more prosperous individuals with the larger houses now receive fire protection on greater value than their neighbors. The inequalities in the domestic use by various families can be adjusted provided the quantity of water consumed in each household can be determined, but how is the increment properly allocated to fire protection to be cared for?

In order that no injustice might be done it would appear to be in order now to divide among the householders—in proportion to the value of the property protected—that increment of the maintenance and operation charges which should properly be allocated to fire protection. This in effect would mean that the community as a

whole would levy a tax on real estate in an amount sufficient to meet the cost of fire protection.

Let us now carry this analysis somewhat further and consider that a business property is erected. As this property is of greater value than other individual properties in the community, it is reasonable to assume that the fire protection afforded this property would be proportional to the value of the same and would be paid for equitably by the tax on real estate. Once it has been decided to raise the cost of fire protection by levying a tax on property, no further problems present themselves.

Let us now consider that a second business property, similar in value, construction, etc., to the first, is built. Naturally no objection would be raised to the assessment of the cost of fire protection on this property on the same basis used in the case of the first business property erected. The potential demand on the water system for the extinguishment of a fire in one of these two properties is no greater than in the other.

Let us assume, however, that the owner of one of these two business properties, for the protection of his interests which in a greater or less degree are the interests of his employees and of his community, decides to install automatic sprinklers as protection against damage from fire, and to supply his sprinkler system from the community mains. A review of the history of fires in sprinklered properties most certainly indicates that the presence of this additional protection within the owner's property not only does not further increase the demand on the water system but actually reduces it.

Naturally, the owner of this sprinklered property expects to assume the cost of installation, either in a cash payment or in some equitable manner. Should the community however decide, as has been done in numerous instances, that, inasmuch as he through his own investment is to receive a benefit greater than the owner of the unsprinklered property, he should pay to the support of the community water system still an additional annual charge for readiness to serve, etc., the owner of the sprinklered building finds himself paying not only his proportional share of the cost of fire protection which is levied against him in proportion to the value of his property but also an additional amount which actually results in lowering that proportion which would otherwise have been contributed by the owner of the unsprinklered property, who now has a greater hazard and a greater potential demand for water.

Discussion by *Harry E. Jordan.* * Mr. Ellis, in his presentation of the fire protection engineer's viewpoint, allows himself to overstate certain aspects of his case. He states "This in effect would mean that the community as a whole would levy a tax on real estate in an amount sufficient to meet the cost of fire protection." This is an ideal condition, the attainment of which can have no greater approbation elsewhere than it would receive from water works executives. But it is an ideal rarely reached. An examination of the income of both water companies and water departments over the land will reveal few instances in which the community levies a real estate tax sufficient to meet the cost of fire protection and turns over the proceeds of that tax to the water department or company.

But Mr. Ellis' discussion proceeds along lines which appear to imply that his ideal condition is commonly in effect. Thus when he refers near the close of his discussion to the prospect of the owner of a sprinklered property paying "still an additional charge for readiness to serve, etc.," he is implying that the owner has already paid his complete share of the cost of all fire protection. But since he generally does not, the force of the argument is lost.

Again, Mr. Ellis refers to a sprinklered risk as one which "does not further increase the demand upon the water system, but actually reduces it." Such reference is only partly correct. The ability of sprinkler systems to reduce water demands under certain conditions is granted. But in communities of medium size, the addition of a sprinklered property may set in motion a train of added requirements extending clear to the supply works.

The meat of the private fire protection coconut lies in the fact that the industries which install such service do so because they are able to develop a sizable saving in insurance costs. These insurance savings frequently amortize the entire installation cost within a few years. The charge made by the water utility for such service as it renders is a valid charge for a real service and when paid will still leave in the purse of the industry a sizable proportion of the saved insurance premiums.

Both public and private fire protection services are valuable and a water department should no more be asked to accept less than the worth of its service than should the installers of the equipment or the insurance companies be asked to furnish their service for less than it is worth.

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* Secretary, A. W. W. A.

Private Fire Protection Charges

By W. D. Masterson

THE question of fire protection charges has been treated in a number of papers read at meetings of this and other organizations and the writer can probably add no great amount to what has been said. The problem is far from solution and it occurs to the writer that the more often it is brought out into the open, the more chance there is that we shall some day get concrete results.

Among the cities represented in the Southwest Section of the American Water Works Association a majority make no charge, though considering only those cities of 50,000 population or more, about half do make some kind of charge and I believe this half will join in urging careful consideration of this subject by all to the end that water works men may secure more support in their fight to retain this source of income.

At the outset it hardly need be said that none of us is fighting against sprinkler installations. They have accomplished much good and should be encouraged, but the question is: Should such installations be subsidized by the water consumers and if so, to what extent. Also, be it noted, they do not need subsidizing in order to grow, for the insurance savings effected are so great in proportion to the cost that a small service charge by the water department will not retard their growth.

Among the papers on this subject which the author has read with much interest have been two of particular importance, one by Robert Nixon and the discussion thereof by Reeves J. Newsom, (Jour. A. W. W. A., **29:** 1837 (1937)) and one by Mr. Newsom and the discussion thereof by John H. Murdock (Jour. A. W. W. A., **30:** 1665 (1938)).

A paper presented on October 18, 1939 at the Southwest Section Meeting at Dallas, Texas, by W. D. Masterson, Manager, San Antonio Water Works, San Antonio, Texas.

It seems to be generally recognized that a large proportion of every city's water department investment and operation is chargeable to fire protection and should not be borne by water consumers as such. But there still is very little being done about it. I can see no more justification in free fire protection water service in a municipally owned water property than in a privately owned one though there are certain matters of offset cost that would naturally change the amount of charge for fire service. The privately owned property pays taxes, a portion of which is for general fire protection purposes. If an estimate of this cost per dollar of water property value could be made then this amount should be deducted from the general charge against the taxes of the city for fire protection service by the water utility.

Unfairness Where Supplies Are Private

Since the value of the water department property is only a small percentage of the total taxable valuation of the city, and only a portion of the tax thereon is for fire protection, the amount of this deduction would be very small and the water utility of almost all large cities should receive from general tax a very substantial payment to cover the cost of fire protection service. This should be especially true in cities where the water property is privately owned or operated on a revenue basis independent of the city tax income. When this is not done the water consumers are paying for fire protection to large property value which in many instances does not contribute to the investment in the water property or its operation cost. Suppose we imagine a city in which one half of the total valuation is served by private water supply. They need fire protection from city mains and if the city gives the water department nothing from general tax the water consumers must carry the load and the other half of property value rides free as far as this item of water service for fire protection is concerned.

Such a condition can not be corrected at once but it weakens the argument of the sprinkler salesman to the effect that his prospective client is already paying for the water department in taxes and therefore should not be made to pay a special charge for his special fire protection outlets.

Many of these sprinklered risks create in the community a dangerous fire hazard out of proportion to the taxable valuation and should be required to take every reasonable precaution to minimize this risk

as much as possible even to the extent of providing a private watchman—but the city should not furnish this watchman. The city in accepting this tax payment obligates itself to give him the same general fire protection and police protection as it gives to others but if this property is of such nature that it should have protection of special officers or watchmen or special fire protection it is the owner's duty to provide it.

The method of charging the city tax fund at a rate simply based on so much per hydrant for general fire protection water service is not scientific or correct. But it is true that the more fire hydrants there are in the city the more chance there is for leakage and wastage and maintenance cost. Every additional connection to the mains increases the cost of service and probability of loss of pressure during storms or large conflagrations. Private fire lines running into and throughout large buildings are more hazardous in these respects than fire hydrant connections.

Example of Service

In one case in San Antonio, some large show windows were provided with sprinkler heads and in the small hours of the morning when the cooling system and fans were turned off, the heat from the extra Christmas lighting in the window, which was left on all night, opened the sprinkler heads. An alarm was sounded but the watchman did not notice it at first and when he did could not locate the valve. He called out the fire department. They in turn called the water department and the street valve was turned off, but not before a large amount of water was wasted and a great amount of damage done. This building has its own private water supply but the fire protection service comes from the city's ten-million-dollar plant paid for and operated by water consumers.

In another case a service to a private sprinkler system broke under the car tracks of a main street. Much damage was done and it was a week before conditions were back to normal. Of course this might happen with any large service but it is figured in as part of the cost of operation and paid for by water consumers. Should not the party benefiting from the service pay his share of costs—or should he ride free because it serves a fire protection purpose for a special fire risk.

In another case our inspector heard a leak noise and finally located it in a drain from a sprinkler system. Without saying anything he placed a meter in the line and after one month found that

the water if charged for on regular rates would have cost $12.50 or if the leak continued for a year, $150.00, whereas the department was collecting $48.00 a year for the service.

There are other special costs of private fire line service which differentiate such service from the costs of general fire protection and it seems that the property responsible for the special fire risk and benefiting from the special protection service should pay something and this should not be merely a nominal charge for monthly inspection. The charge would naturally vary according to local conditions, but the variation should not be from zero to $400 a year as it is now.

We have been working a long time on water rates. In some instances water service was furnished from general tax funds and no special charge assessed to users. Then came the flat rate; then the meter rate; and now in most cases a combination of the two in the readiness to serve charge and consumption charge. A private fire protection charge is primarily a readiness to serve charge and should be much less than other readiness to serve rates for equal size connection to mains because of the nature of the service and the improbability of maximum demand being made. There should be, however, a charge embracing part readiness to serve and part maintenance service.

Use of Protectus and Detector Meters

Quite a number of cities now require protectus meters or detector meters with a weighted check valve, the latter is perhaps the more popular arrangement. We are planning to require a detector meter in cases where private supply is used for ordinary service and city supply only for fire protection. Since the detector meter does not afford an accurate measure of water flowing through the fire line but merely an indication that water has been used, it is our plan to make the regular charge to such places but read the meter every month and if it is indicated in any month that water has been used we shall charge for that month the regular meter minimum for the size of fire line connection to the city main. Of course this excepts water used for fire fighting purposes.

One odd feature about rate controversies of this type is that in many cases the fight is instigated and kept alive by those interested in increased sales of sprinkler equipment. Personally I think these groups make a mistake in antagonizing water departments by trying to force them into rendering this service without charge.

If a water department received fair compensation for service rendered it would cooperate more in trying to increase such installations.

National Fire Waste Council Opinion

In one of our recent controversies on this question in San Antonio, a sprinkler friend gave the opposing counsel a booklet issued by the National Fire Waste Council which according to his interpretation advocated free service to sprinkler installations. Since the 24 memberships in the National Fire Waste Council embraced most of the important national organizations excepting the American Water Works Association, it seemed to be a knockout blow to our side but upon reading the document over it did not seem half so bad. The foreword reads as follows:

"It is the concensus of opinion of the members of the National Fire Waste Council that the installation of private fire protective equipment will do much to reduce the fire waste of the nation. It believes that any system of apportioning charges for water used for fire protection purposes not based upon the actual cost of production is inimical to the welfare of property owners in general; that prices charged should be in harmony with costs as determined by an adequate method of cost accounting; that a rate so derived will foster the extension of both private and public fire protection with attendant benefits to the community in general."

This report was submitted to the membership at its spring meeting March 27, 1939, and received unanimous approval.

We can not take issue with this statement and if this is all that was agreed to by the representatives of the various national organizations I think they could have included the name of the American Water Works Association with the others. The booklet in discussing the matter under the heading of "Source of Revenue," states that "If (and it emphasizes the word "If") financial arrangements are made to provide fire protection water service from general tax then no additional special tax should be charged sprinkler services. With this I do not agree and I am not sure that this was endorsed by the 24 members of the Fire Waste Council for a representative of the National Board of Fire Underwriters, one of the 24 members, came to San Antonio and after studying our rates said he thought they represented a fair special service charge. At any rate, if we refer back to the word "If" preceding, it seems logical to assume that when financial arrangements are not made to provide proper revenue from

general tax for fire protection water service then the water department is justified in securing this revenue elsewhere. I do not think it should be assessed against water consumers but rather that it should be in the form of a special charge against the city (which might or might not be collected) for all outlets or appurtenances on city property and under direct control of the water department, and in the form of a charge against private individuals for all outlets or appurtenances on private property which are beyond the supervision and control of the water department.

No Charge in Smaller Cities

Statements have been made that San Antonio is a rare exception in this matter of charging for private fire protection service, probably because the majority of cities in this section make no such charge—but from a list of 132 cities reported in 1933, when our last controversy was in progress, we found that 100 were making some such charge and the average charge of these 100 was higher than the San Antonio charge.

In a recent series of rate publications in the American City magazine it is true we find only a few making this charge, but most of the cities thus far reporting were small and would therefore be affected little if any by such charge. Considering only cities of 50,000 population or over, it will be found that, of ten reported, seven have charges.

To summarize, it seems to me that a portion of general tax should be allocated in some way to the water department to cover a fair estimate of the cost of readiness to serve for general fire protection but that, whether this is done or not, there should be a reasonable special service charge for private water outlets existing on private property primarily for private benefit and beyond the control of the water department.

In cases where this service is rendered to private property with private water supply, using public supply only for fire protection convenience or economy, a protectus meter or a detector meter of some kind should be required and a contract providing that if during any month there is indication of water usage for any purpose other than fire fighting, then for that month the regular meter minimum of the size service connection to the main shall be charged.

On fire service lines having any outlets other than automatic sprinkler heads, meters should be installed and regular meter rates should prevail.

San Antonio does have some fire services that are not all sprinkler head and which pay a flat rate but this is not allowed on new contracts and there are flat rate fire service contracts to some properties having private water supply but on new contracts of this type detector meters will be required. The present schedule of fire protection charges is as follows:

Private Fire Protection Rates in San Antonio

Annual Net Charges—Payable in Advance.

If a majority of the area protected is covered by recognized sprinkler service the following schedule shall prevail:

Main Control Valve, 4-inch, minimum charge $48.00 and maximum charge $48.00.

Main Control Valve, 6-inch, minimum charge $48.00 and five cents added for each sprinkler head over 200 up to a limiting maximum charge of $66.00.

Main Control Valve, 8-inch, minimum charge $72.00 and five cents added for each sprinkler head over 500 up to a maximum charge of $96.00.

A discount of 10 per cent is allowed if A.D.T. Alarm service is in active use.

Our readiness to serve charge for a 6-inch metered service is $32 a month or $384 a year for which however a considerable amount of water is allowed if wanted. The 6-inch fire line should not be charged so much for several reasons. First, the water allowance if used at all would probably be used anyhow through city fire hydrants for the use of which payment has already been made in general tax (even though the water department probably did not get its share of that tax). Second, it is not so apt to produce its maximum demand as is a regular 6-inch metered service. On the other hand it is more apt to have wastage and unaccounted for water than the regular metered service. As mentioned before our net charge for 6-inch size varies between $43.20 and $66 per year. In many cases, less than $4 a month.

If a majority of the area protected is not covered by sprinkler service but by hose connection then, on new installations, meters will be required but on existing installations the following flat rates will be allowed: 4-inch, $80.00; 6-inch, $96.00; and 8-inch, $150.00.

On new installations to sprinkler systems on property using regular water service from a source other than the city mains a detector meter of make to be approved by the city will be required and if

during any month water usage is indicated by the meter and no fire existed, then, for that month, the regular meter minimum shall be charged based on a meter of same size as service connection to city main.

All costs of service installation including main extension if necessary and detector meter if required must be paid by the applicant for service.

One other regulation that is being made in some cities which I think a good one though not yet adopted in San Antonio is that no private fire protection service be installed of a size greater than 2-inch diameter under the diameter of the main to which it is to be attached. In case a 6-inch service is demanded and only a 6-inch main is available the applicant is required to pay for replacing the 6-inch main with 8-inch back to the nearest 8-inch or larger main available.

Private fire protection service is like insurance. It should be paid for whether it is used or not and the party paying should hope it will never be used but nevertheless feel he is buying a certain security.

Discussion by *G. L. Fugate.* * We agree with Mr. Masterson that the installation of private fire systems should be encouraged, and in such a manner that the water utilities will have the good will and full cooperation of the manufacturers of the equipment used in them. Such cooperation will protect the best interests of the utilities, the manufacturers and the owners. It is believed that obtaining this cooperation can best be approached by each utility analyzing thoroughly its particular problem and applying more of the fundamental concepts of rate making than has been the practice in the past. The trial and error, haphazard methods often used, no doubt, create a great deal of friction and dissension among the utilities, manufacturers and owners.

Mr. Masterson's illustrations of how the probability for loss of pressure and property damage in the system is increased, possibly during critical times, indicate some of the responsibilities assumed by water utilities in supplying private fire connections. Obviously such responsibility should not be assumed without due remuneration any more than the responsibility for other forms of liability or insurance should be assumed without pay.

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* Chief Engineer, Water Department, Houston, Texas.

To Mr. Masterson's citations of papers previously published, I shall add a paper by L. R. Howson, (Jour. A. W. W. A., **23:** 955 (1931)) which is a very complete analysis of this problem. It should be read by all who are interested in the fundamentals of private fire protection service.

Problems in Houston

Some of the experiences in Houston may be of interest and value. All of you know a rapid growth in population has been experienced in Houston for the past two decades. During most of this time the revenue from the water department was diverted into the general fund, and the amount budgeted back to the department each year was insufficient to provide efficient operation. Financial assistance was inadequate for expansion to meet the growing demands. High water rates for large consumption encouraged the drilling of private water wells for industrial use, resulting in less revenue to the department, thus adding to the vicious cycle. Likewise, the fire department was unable to keep pace with the growth. So the nationally recognized standards could not be complied with. A great deal of tolerance was shown in allowing so called "temporary structures" to be built in the fireproof zones, thus creating what were considered fire hazards. The combination of these brought about a relatively high key rate for insurance of which the water department is charged with deficiencies amounting to nearly 25 per cent of the total key rate.

Because of the key rate, large industries could realize a considerable saving in insurance premiums by installing private fire systems connected to the public water supply; in a few instances these are cross-connected to the industries' private supplies. Some of the systems are elaborate, consisting of mains, fire hydrants, hose racks, elevated tanks and automatic sprinklers and covering several acres of ground.

The city ordinances require metering of all connections to the public water system, but, for several years, they were not enforced for private fire connections. This lack of enforcement was due, possibly, to the reason that the department felt a responsibility because it had not kept pace with the growth of the city and was willing to assume some of the responsibility in this manner; and, partly, because metering devices for fire lines had not been developed as fully as they are today.

Under those conditions such a policy may have been justifiable. But as the department became more nearly able to meet reasonable demands made upon it, this policy rightfully was changed. Along with attempts at general reorganization of the department, machinery was set in motion to close the gap between water billed and pumped. As part of this work, the policy of metering all new private fire connections was considered, but it was decided, tentatively at least, to install measuring devices on the open type systems only and not on the closed alarm sprinkler type.

A section was set up, whose manager was later dubbed with the name of "Water Detective." Its function was to discover and have corrected the use of unmetered and unauthorized water. Casual inspection indicated that some of the existing large private fire systems had not been maintained to the best advantage, and it was possible that unmetered water was wasted through leakage. In some instances connections were found in the fire system for uses other than fire protection. However, there is no evidence that such connections had been made willfully or with the knowledge of the executives of the industries. They had been made, usually, by someone unfamiliar with the system.

Unfavorable Publicity

In cooperation with the industries, a general inspection of all fire systems was begun. This was considered a matter of routine only, but the work had scarcely begun until someone decided it was "news." Before long newspaper boys appeared on the streets yelling, "Read about the Big Water Theft"; large headlines across the front page of the papers read: "33,000 Dollar Water Theft Uncovered." This created the usual seven day wonder, and in some of the items published there were vague insinuations that large industries were willfully using water for which they did not pay. These insinuations naturally and rightfully brought about resentment and indignation among those with whom we were cooperating in making the inspections. But, fortunately, we were dealing with men of high business standards and ethics, and they were soon convinced that these publications were not by authority of the executives of the water department.

The work has progressed so that fourteen meters of the detector check type and four of the fire flow type have been installed. Detector checks with bypass meter and check indicators are used where

separate meters measure the supply for uses other than fire protection; meters of the fire-flow type are used where the different uses are combined through a single connection. Some of the results are shown in tables 1 and 2. The department at Houston uses 10 per cent of the investment in gross revenue per annum as a guide in extending mains; that is to say, if an extension will return revenue per annum equal to 10 per cent of the cost, it is profitable. If the same token is used as a guide in the economies of the above installa-

TABLE 1

Detector Checks

INSTALLATION	AVE. GAL./ MONTH	TYPE OF SYSTEM	INSTALLATION	AVE. GAL./ MONTH	TYPE OF SYSTEM
A	20	Closed	I	810	Open
B	25	Closed	J	7,825	Open
C	7,500	Open	K	193,600	Open
D	6,800	Open	L	31,400	Open
E	22,400	Open	M	145,000	Open
F	100,200	Open	N	46,400	Open
G	5,600	Open			
H	5,100	Open	Total	572,680	

TABLE 2

Fire Flow Meters

INSTALLATION	INDICATED INCREASE IN GAL., AVE./MONTH
A	1,185,000
B	94,500
C	1,074,000
D	56,500
Total	2,410,000

tions, the revenue may be capitalized at $56,500; the cost of the installations was about 23 per cent of this amount.

It may be noted here that the per cent of water billed to the water pumped has increased materially. Of course, only a small part of this increase is due to the metering of private fire systems. It has been brought about, to a large extent, by more effective operation and maintenance in all sections of the department of which the metering of private fire lines is one unit of the work.

Based on this experience and the fundamental concepts of rate making, we have formed these conclusions:

1. Private fire service is a highly specialized service made available by the construction and operation of the public water utility.

2. This specialized service is a "readiness-to-serve" service, and the cost of it should be paid for as such a function.

3. All open types of private fire systems should have installed on them a metering device.

4. It seems probable that the closed alarm type of system may operate satisfactorily without undue waste of water if the water utility makes frequent inspections. These inspections add to the cost of "readiness-to-serve" and a higher rate than for those systems equipped with meters should be charged.

Hydraulics and Water Works Engineering

By H. N. Lendall

Part 2

Friction Losses in Pipe Lines

WHEN water flows in a pipe line, a considerable part of the available head is lost in overcoming frictional resistances. The losses of head due to friction are:

1. Loss at entrance to a pipe line.
2. Loss due to friction of the interior surface of the pipe walls and internal friction between the water particles.
3. Losses due to curves, sudden enlargements and contractions, pipe fittings, valves and submerged discharge.

The loss at the entrance depends on the manner in which the connection is made. It is generally expressed as $k_e \frac{v^2}{2g}$ where "v" is the velocity in the pipe. Values of k_e are as follows:

Bell-mouthed entrance	$k_e = .04$
Conical entrance	$k_e = 0.18$
Non-projecting pipe	$k_e = 0.50$
Projecting pipe	$k_e = 0.78$

In a previous discussion (Jour. A. W. W. A., **30**: 2066) it was shown that pipe friction could be expressed as

$$h_f = \frac{fl}{d} \frac{v^2}{2g}$$

where

l = length
d = diameter of pipe in feet

A paper presented on February 7, 1939 at the New Jersey Section Meeting at New Brunswick, N. J., by H. N. Lendall, Professor of Municipal and Sanitary Engineering, Rutgers University, New Brunswick, N. J. Part I of "Hydraulics and Water Works Engineering" has been published previously—Jour. A. W. W. A., **30**: 2063 (1938).

$\frac{v^2}{2g}$ = velocity head

f = factor dependent on the interior condition of the pipe.

TABLE 1*

Values of "f" for Clean, Smooth Cast-Iron Pipes

DIAM.	VELOCITY IN FEET									
	1	2	3	4	5	6	8	10	15	20
inches										
4	.0285	.0255	.0240	.0230	.0225	.0220	.0210	.0200	.0190	.0180
5	.0275	.0245	.0230	.0225	.0215	.0210	.0200	.0195	.0185	.0175
6	.0265	.0240	.0225	.0215	.0210	.0200	.0195	.0190	.0175	.0170
8	.0255	.0230	.0215	.0205	.0200	.0195	.0185	.0180	.0170	.0160
10	.0245	.0220	.0205	.0200	.0190	.0185	.0180	.0175	.0165	.0155
12	.0235	.0215	.0200	.0190	.0185	.0180	.0175	.0170	.0160	.0150
15	.0230	.0205	.0195	.0185	.0180	.0175	.0170	.0165	.0155	.0145
18	.0220	.0200	.0190	.0180	.0175	.0170	.0165	.0160	.0150	.0140
20	.0215	.0195	.0185	.0175	.0170	.0165	.0160	.0155	.0145	.0140
24	.0210	.0190	.0180	.0170	.0165	.0160	.0155	.0150	.0140	.0135
30	.0200	.0185	.0175	.0165	.0160	.0155	.0150	.0145	.0135	.0130
36	.0195	.0180	.0170	.0160	.0155	.0150	.0145	.0140	.0130	.0125
42	.0190	.0175	.0165	.0155	.0150	.0145	.0140	.0135	.0130	.0125
48	.0185	.0170	.0160	.0155	.0150	.0145	.0140	.0135	.0125	.0120
60	.0180	.0165	.0155	.0150	.0145	.0140	.0135	.0130	.0120	.0115
72	.0175	.0160	.0150	.0145	.0140	.0135	.0130	.0125	.0120	.0115
84	.0170	.0155	.0145	.0140	.0135	.0130	.0125	.0120	.0115	.0110
96	.0165	.0150	.0140	.0135	.0130	.0125	.0120	.0120	.0110	.0105

* *Hydraulics* by G. E. Russell.

TABLE 2

Values of "f" for 2½-inch Fire Hose

DESCRIPTION OF HOSE	VELOCITY IN FEET				
	4	6	10	15	20
Unlined Canvas	.038	.038	.037	.035	.034
Rough Rubber-lined Cotton	.032	.031	.031	.030	.029
Smooth Rubber-lined Cotton	.024	.023	.022	.019	.018

The above expression shows that for a line of constant length and diameter the friction loss will increase with an increase of velocity;

also that for a fixed head, an increase in the length of the pipe line will cause a decrease in velocity and hence of the discharge.

The factor "f" will vary with the velocity, diameter, material and age of the pipe. Values of f for new cast-iron pipe and for $2\frac{1}{2}$-inch fire hose are shown in tables 1 and 2. Losses due to curves, fittings, valves, etc., as given above under item 3, have been determined experimentally but there is still need for much further investigation. The losses are with one or two exceptions in the form of $k\frac{v^2}{2g}$. The following are some values used in practice.

$$\text{Sudden expansion } \frac{(v_1 - v_2)^2}{2g}$$

$$\text{Sudden contraction } k_c\frac{v^2}{2g}$$

For $\frac{A_2}{A_1}$	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.00
$k_c=$	.47	.43	.39	.34	.30	.21	.21	.16	.08	0

Pipe Fittings	loss $= k\frac{v^2}{2g}$
Globe valve, wide open	$k = 10$
Angle valve, wide open	$k = 5$
Close return bend	$k = 2.2$
Tee, through side outlet	$k = 1.8$
Short radius elbow	$k = 0.9$
Medium radius elbow	$k = 0.75$
Long radius elbow	$k = 0.60$
45-degree elbow	$k = 0.42$
Gate valve, wide open	$k = 0.19$

$$\text{Submerged discharge loss} = \frac{v^2}{2g}$$

In the design of long pipe lines it is customary to neglect all losses except that due to pipe friction. A long pipe line may be considered one that is in excess of 500 to 1,000 diameters. However, the minor losses should be considered where they constitute an appreciable part of the head lost.

Consider a pipe line connecting two reservoirs as shown in fig. 5. If a piezometer tube is placed at A, water will rise to some height

A-A' which will equal the pressure head at that point. If a valve placed at D were closed, the water would rise to E at the same elevation as water in the reservoir at F. The drop from E to A' when flow is taking place is due to the head producing the velocity and the friction loss between the reservoir and point A. If a series of piezometer tubes were erected at points along the whole line the water would rise in them to various levels. If a line were drawn through the summits of these water columns, this line would show the pressure head at any point in the pipe. This line is called the hydraulic grade line or hydraulic gradient.

The hydraulic gradient shows very clearly the pressure variation. It has a very practical application in that the profile of a proposed pipe line can be drawn to scale and by computing a few points, the hydraulic gradient can be drawn and the pressure at any point

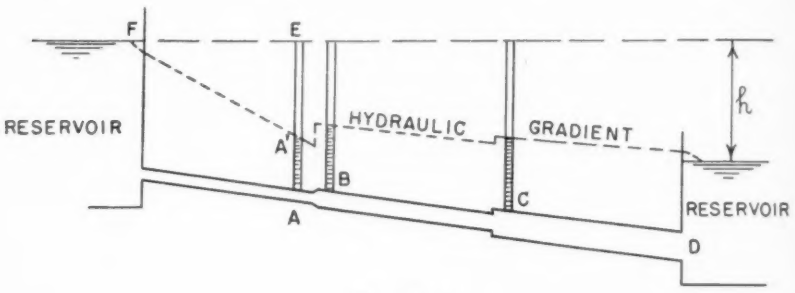


FIGURE 5

determined. It can also be used to determine the diameter of a pipe line to meet discharge and pressure requirements.

It is to be noticed (fig. 5) that the distance from the water surface at F to the hydraulic gradient represents the friction loss plus the velocity head. The following problem illustrates the above method for determining the size of pipe for a supply line required to deliver a certain quantity of water at a definite pressure.

Assume that this line is to deliver 6 million gallons per day or 9.28 cubic feet per second, at a pressure of 60 pounds per square inch at the city end. A profile of the line is shown in fig. 7, elevations being shown in hundreds of feet and distances in thousands of feet.

The diagram, fig. 6, shows the relation between rate of flow, diameter of pipe, head loss due to friction in feet per thousand feet of length and velocity in feet per second. To use this diagram,

QUANTITY - GALLONS PER MINUTE

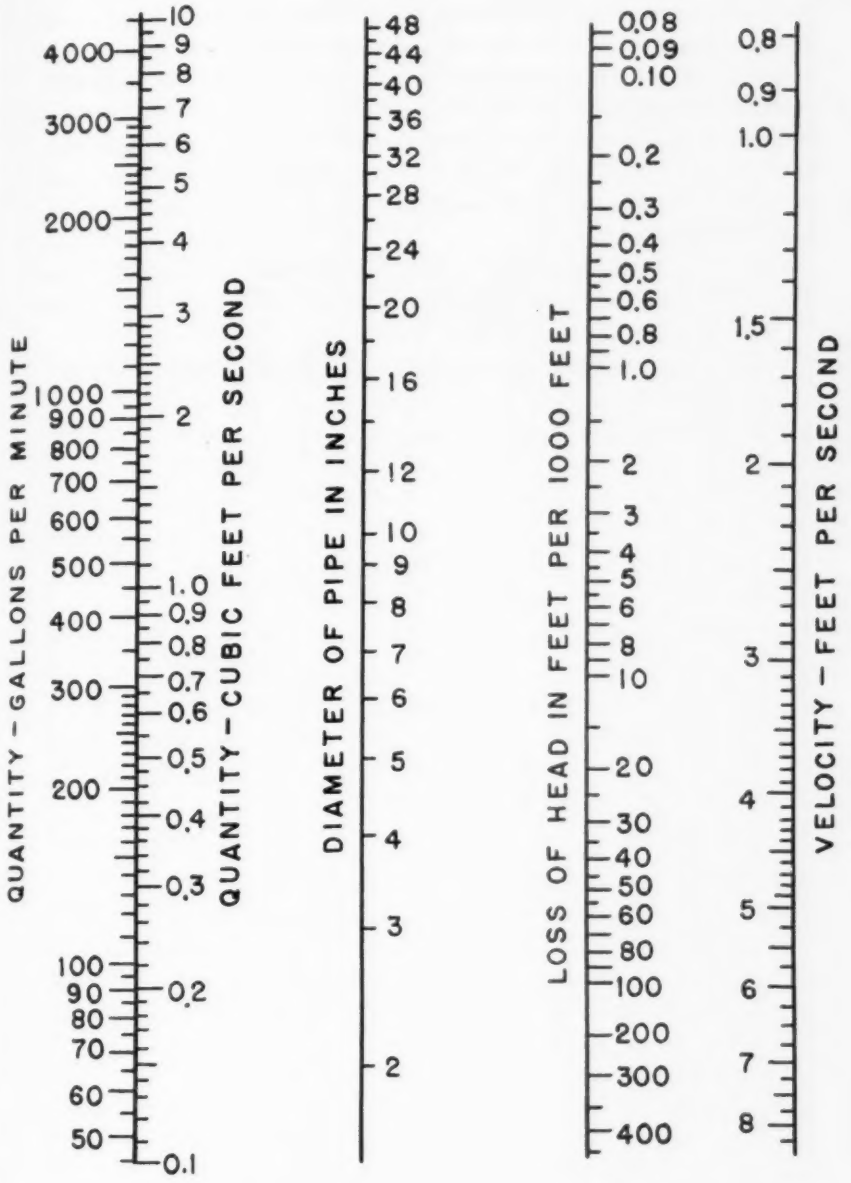


FIG. 6. Pipe Flow Diagram for Cast Iron Pipe

place a straight-edge on 9.28 c.f.s. on the "discharge line" and on 20 on the "pipe-size line." The straight-edge will intersect the "loss-of-head line" at 4.8 showing the loss of head as 4.8 ft. per 1,000 ft. of pipe. It will intersect the "velocity line" at about 4.2 showing a velocity of 4.2 ft. per sec. A loss of head 14 ft. per 1,000 ft. of pipe and a flow of 9.28 c.f.s. would require a 16-inch pipe. Thus with the aid of this diagram, if we know any two quantities, the other two may be determined.

Returning to the problem, on fig. 7 in the lower left-hand corner are plotted lines representing the friction loss in 12- 16- 20- and 24-

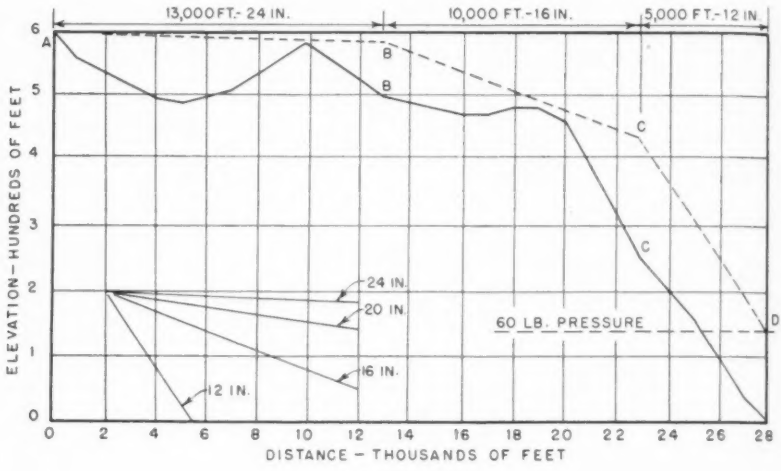


FIGURE 7

inch pipe for various lengths up to 10,000 ft. for a flow of 9.28 c.f.s. The friction losses have been determined from the diagram, fig. 6.

If, from point *A* on the profile, lines are drawn parallel to those representing the friction losses in the different sizes of pipe, we find that a 24-inch pipe will be required to point *B*, a distance of about 13,000 ft. From previous discussions it will be remembered that the hydraulic gradient shows the pressure head and friction loss at any point in a pipe line; further that the hydraulic gradient must always be above the pipe line in order that constant flow conditions may be maintained. The dotted line *A*-*B* is the hydraulic gradient for the pipe line *A* to *B*. In a similar manner we find that a 16-inch pipe will be required from *B* to *C* and a 12-inch from *C* to *E*.

It will be noticed that the pressure head at *E* is 138 ft. or 60 lb.

per sq.in. It is not always possible to design a pipe line that will give exactly the pressure desired. This could be done if we were not limited to the use of commercial sizes of pipe.

As a check on the above graphical method we have the difference of elevation between the reservoir and city as 600 ft. The tabulation below indicates the check.

Difference in elevation		600.00 ft.
Friction loss, 13,000 ft., 24-inch	26.00	
Friction loss, 10,000 ft., 16-inch	143.00	
Friction loss, 5,000 ft., 12-inch	290.00	459.00 ft.
Pressure head at *E*		141.00 ft.
		or 61 lb. per sq. in.

Part 3
Distribution System Planning

IN THE two previous papers which have been given on this subject we have discussed the friction losses due to flow of water in pipe lines and the characteristics of the hydraulic or pressure gradient.

It is the purpose of this paper to show the application of some of these principles to the analysis of distributing systems.

There are three general types of distributing systems: (1) the circular system, (2) the gridiron system and (3) the so-called tree system. The circular system is an arrangement whereby large mains circle a section or district and small pipes are connected to the circle at each end. Such a system generally gives more uniform service and less pressure variation. The gridiron system may be similar to the circle system but often pipe sizes decrease in outlying districts giving unsatisfactory service and low pressures. The tree system is the result of additions and extensions in accordance with the growth and demand of the community. It consists of single lines with branches which decrease in size as the distance from the source of supply increases. This type of system is the least desirable.

A paper presented on October 20, 1939 at the New Jersey Section Meeting at Atlantic City, N. J., by H. N. Lendall, Professor of Municipal and Sanitary Engineering, Rutgers University, New Brunswick, N. J.

There is no direct method of designing a distributing system. The usual method is to lay out the system with assumed sizes of pipe and then investigate the layout by computing the pressures and rates of flow at various points throughout the system. The pressures and flows must meet the demand and provide adequate fire protection.

It can be seen that the analysis of a whole system is an extremely complicated problem. Several methods to simplify the computations have been proposed. In the problems which follow we shall, for the most part, keep to the cut-and-try method.

Let us first consider a single pipe line consisting of 2,000 ft. of 24-inch, 1,500 ft. of 16-inch, and 1,000 ft. of 12-inch pipe. It is desired to replace the line with a pipe of uniform diameter that will deliver the same quantity of water with the same loss due to friction.

Assuming a flow of 3,000 gallons per minute and referring to fig. 6, we obtain:

PIPE SIZE	LENGTH FEET	FRICTION LOSS	
		ft./1000	Total
inches			
24	2000	1.1	2.2
16	1500	7.8	11.7
12	1000	31.0	31.0
Total loss in the line			44.9

Length of the line is 4,500 ft.

Loss per 1,000 ft. = 44.9 ÷ 4.5 = 9.95 ft.

Referring to fig. 6, a flow of 3,000 gallons per minute and friction loss of 9.95 ft. would require a 16-inch pipe. Thus a 16-inch pipe line 4,500 ft. long is practically equivalent to a line consisting of 2,000 ft. of 24-inch, 1,500 ft. of 16-inch, and 1,000 ft. of 12-inch pipe.

It is to be noted that the line intersection 3,000 g.p.m. and 9.95 friction loss per thousand feet on the pipe diagram, fig. 6, cuts the "pipe size" line between 14 and 16 inches. This indicates that the 14-inch pipe is too small and the 16-inch too large. Since we are confined to the use of commercial size pipe, the 16-inch size would have to be adopted.

It will be seen that 4,500 ft. of 16-inch pipe having a friction loss of 9.95 feet per thousand will have a capacity of 3,500 g.p.m.; and when carrying 3,000 g.p.m. will have a friction loss of 7.8 ft. per thousand giving a total loss of 35.1 ft.

We may now define an "equivalent pipe" as one which will carry the same rate of flow with the same drop of head or friction loss as another pipe or series of pipes of a given length. Thus we may find the equivalent diameter of a pipe for a given length or the equivalent length of a pipe of given diameter.

In order to illustrate the last statement of the previous paragraph we shall determine the length of 16-inch pipe which is equivalent to 3,000 ft. of 24-inch pipe.

Let us assume 2,500 g.p.m. as the flow in the 24-inch pipe and from fig. 6:

Loss per 1,000 ft. = .77 ft. Total loss = 2.31 ft.

For flow of 2,500 g.p.m. in 16-inch pipe:

Loss per 1,000 ft. = 5.6 ft. and equivalent length of 16-inch pipe is

$$\frac{2.31}{5.6} \times 1000 = 413 \text{ ft.}$$

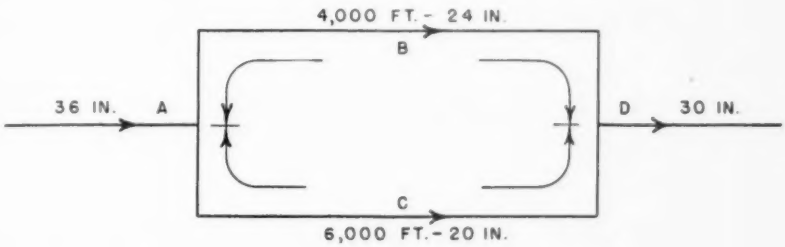


FIGURE 8

As a second application let us investigate the layout shown by fig. 8 where a 36-inch line divides into 24-inch and 20-inch lines and these lines later merge into a 30-inch line. First let us find how a flow of 4,500 g.p.m. will divide through the branches *A-B-D* and *A-C-D* and what the pressure drop will be from *A* to *D*. This would be solved by trial. Assume 1,500 g.p.m. through the 20-inch. The loss per 1,000 ft. is 0.73 ft. and the total loss is 4.38 ft. The pressure drop through *A-C-D* must equal that through *A-B-D*. Hence in the 24-inch line, the loss per 1,000 ft. is 4.38 ÷ 4 or 1.10 ft. Flow in the 24-inch with a loss of 1.10 ft. per 1,000 ft. from fig. 6 is 3,000 g.p.m. and 3,000 + 1,500 = 4,500 g.p.m. The drop in pressure from *A* to *D* is 4.38 ft.

Suppose it is desired to install a single line of pipe from *A* to *D*

to replace the two branches and to carry the combined flow of 4,500 g.p.m. with the same drop of head. If the distance from *A* to *D* is 3,000 ft. and the loss of head as given above is 4.38 ft. then the loss per 1,000 ft. is 1.1 ft. and, from fig. 6, the required size of pipe would be 30-inch diameter. With this size pipe the loss between *A* and *D* would be about 2.34 ft. For a 24-inch pipe, the next smaller size, the loss would be 2.29 ft. per 1,000 ft. of pipe or 6.87 ft. from *A* to *D*.

The following example is the analysis of a small system in which the main feeders are shown in fig. 9. This is a gravity system and the design data are as follows:

Flow from reservoir at Point 6 to 5 is 13,000 g.p.m. through 15,000 feet of 36-inch pipe, with a pressure drop of 86.00 ft. Since the elevation at (6) is 500 ft. and that at (5) is 200 ft., the pressure head at (5) will be 300 − 86 = 214 ft. or 93 lb. per sq.in.

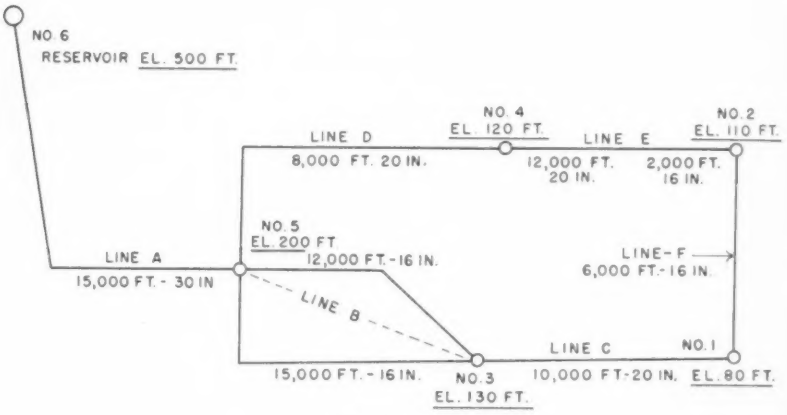


FIGURE 9

We will further assume that the following quantities of water were delivered at points (1) to (5) inclusive on a day of maximum demand and a 20 stream fire lasting for 12 hours at point (1)

Point 1—5,670 g.p.m.
Point 2—2,500 g.p.m.
Point 3—2,900 g.p.m.
Point 4—1,500 g.p.m.
Point 5— 750 g.p.m.

It is desired to find the pressure in the mains at points (1) to (5) inclusive for the above conditions.

We know that the total drop in pressure from point (5) to points (3) and (1) is equal to the drop from point (5) to points (4), (2) and (1).

We will first simplify the double line from point (5) to point (3) to an equivalent main of 20-in. diameter.

Using the method already described in the previous example we find the equivalent length to be 11,000 ft. of 20-inch pipe. We will next simplify the compound line from point (4) to point (2) to an equivalent 20-inch main. By the same method as above the equivalent length is found to be 18,000 ft. of 20-inch pipe.

Using a method of trial we will balance the pressures at point (1) by assuming flows in both branches.

TABLE 3

Pressure Heads at Points (1) to (5)

LINE	FROM	TO	SIZE		FLOW IN G.P.M.	LOSS OF HEAD		RESIDUAL PRESSURE AT POINT IN COL. 3			
								Elevation in Feet		Pressure in pipe	
			Diam. in in.	Length in 1000 ft.		In Feet per 1000 ft.	Total in line Feet	Hydraulic Grade Line	Pipe	Feet	lb. per sq.in.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	6	5	30	15.0	13,350	5.74	86.0	414.0	200	214.0	93
B	5	3	20	11.0	6,850	12.15	133.6	280.4	130	150.4	65.4
C	3	1	20	10.0	3,950	4.32	43.2	237.2	80	157.2	68.3
D	5	4	20	8.0	5,750	8.75	70.0	344.0	120	224.0	97.4
E	4	2	20	18.0	4,250	4.99	89.8	254.2	110	144.2	62.6
F	2	1	16	6.0	1,750	2.83	17.0	237.2	80	157.2	68.3

Assuming the flow from point (5) to point (3) to be 6,850 g.p.m., the loss of head will be 133.6 ft.

The flow through line *C* will be 6,850 g.p.m. less 2,900 g.p.m. left at point (3) or 3,950 g.p.m. The loss of head will be 43.2 ft. The total loss of head from point 5 through line *C* to point (1) is 176.8 ft.

Since the flow from point (5) to point (3) was assumed to be 6,850 g.p.m. the flow through line *D* would be:

$$13{,}350 - 750 - 6{,}850 = 5{,}750 \text{ g.p.m.}$$

and the loss of head = 70.0 ft.

The flow from point (4) to point (2) would be:

5,750 − 1,500 (left at (4)) = 4,250 g.p.m.

The head loss is 89.8 ft.

The flow in line *F* is:

4,250 − 2,500 (left at (2)) = 1,750 g.p.m.

The head loss is 17.0 ft.

The total head loss from point (5) through line *D* to point (1) is 70.0 + 89.8 + 17.0 = 176.8 ft.

The difference in elevation between point (5) and point (1) is 200 − 80 = 120 ft. The pressure head at point (5) has been found to be 214 ft. Hence the pressure head at point (1) is 214 + 120 − 176.8 = 157.2 ft. or 68 lb. per sq.in.

Table 3 gives the results of the above computations and shows the pressure heads at the points (1) to (5).

The last illustrative problem involves quantities such that a diagram more extensive than fig. 6 is required. The solution of this problem is given, however, to show a method of approach which may be employed in the analysis of more extensive and complicated distributing systems.

The Maintenance of Electrical Equipment In Water Works

By C. J. Schoeninger

THE days of the hay-wire mechanic are over. No longer can the electrical maintenance man qualify by the use of a screw driver and a pair of pliers. It is necessary that he have a working knowledge of the fundamentals of electricity, that he know and understand the operation of electrical instruments if he is to be able to diagnose electrical ailments, prescribe a treatment for their cure and prevent their recurrence.

In order to make minor adjustments and repairs, he must have at least a general understanding of the electrical and mechanical characteristics of the apparatus under his care. He should be provided with the manufacturers' instruction books, together with wiring diagrams and connections. No maintenance man's kit is complete without an ammeter, volt-meter, watt-meter and megger. If he is to get to the heart of the trouble he must have the proper equipment and tools.

The first requirement in the satisfactory maintenance of electrical apparatus is competent inspection. General conditions should be determined by a thorough initial inspection, after which a systematic maintenance schedule should be established.

Many systems of planned maintenance are possible and each has its advantages. Details are less important than the main points to be covered, which are these:

1. Set up a complete schedule for maintenance, covering all items.
2. Include cleaning, inspection and lubrication.
3. Adopt some simple check forms, noting when jobs are due, and trial operations to be performed.

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4. Assign every motor and its control a number.
5. Assign each job to some individual.

Maintenance work for all equipment should be organized on the basis of correcting as completely as practicable the depreciation caused by electrical, mechanical and conditional agencies, which constitute the enemies of continuous operation.

There is necessarily a great difference in the treatment of the different kinds or assemblies of apparatus. Specific instructions, as supplied by the manufacturer for each unit of equipment, should always be followed.

Effective maintenance to a large extent depends upon cooperation of the operating personnel in reporting defective equipment. It is well to establish a hard and fast rule that any abnormal operating condition *must be reported* at once.

Electrical maintenance in the water works involves the keeping in service of motors, generators, switching equipment, protective devices and other electrical appurtenances for the proper delivery of water to distribution mains and consumers. In this paper there will be considered the four major and most commonly used apparatus, namely, motors, controls, transformers and instruments.

Safety in Maintenance Work

Every precaution should be taken to see that line switches are open and properly tagged before starting any inspection or repair work. The importance of this cannot be over emphasized. When a piece of apparatus shows signs of trouble, it should immediately be removed from service. To accomplish this, some form of record for apparatus service interruption should be established. It should include such information as why the equipment has been taken out of service, who requested the release, the nature of the work to be done and the approximate time that the equipment will be out of service. The record should show which switches, oil circuit breaker and control circuits have been tagged. When the inspection or repair work has been completed, the person making request for interruption should in turn sign a release of the equipment. If such a policy is adopted, each individual will be responsible for the performance of work assigned to him, and the accidental opening or closing of apparatus causing injury to workmen or interruption of services will be prevented.

Motors

There are so many sizes and types of motors used, under such a variety of circumstances, that it is difficult to enumerate them in a short paper. The most popular and commonly used motors are the squirrel cage and wound rotor, three-phase induction type, and the direct current shunt and compound. Induction motors are built in a number of different forms, to obtain different speed and torque characteristics. Direct current motors are made in three general types and differ in respect to the arrangements of the field windings. Due to the complications involved, no effort will be made to discuss the various types of motors and their application, as each installation differs as to speed and torque requirements.

A good alternating current motor, operating within its rating and kept clean and dry, may run indefinitely. This presupposes periodic inspection and oiling of bearings.

The direct current motor with its commutator, brushes and brush riggings requires considerably more attention and closer inspection. The importance of keeping motors clean and dry is always worth stressing. There is no substitute for cleanliness. The majority of motor failures can usually be traced to one of the following causes: worn bearings, moisture, overloading, operating single phase or poor insulation.

For cleaning motors, compressed air and vacuum devices have come into wide use. The vacuum cleaning is preferable, as it removes the dirt entirely and does not blow it from one place to another, as does compressed air. If compressed air is used, care should be taken to see that the air is dry and throttled down to a pressure not to exceed fifty pounds. Otherwise, the air will damage the windings.

As the useful life of any motor depends largely upon the condition of the insulation, every precaution should be taken to protect the windings. The windings appear to be so simple and rugged that they are frequently overlooked in the general maintenance procedure. Insulation on machine windings tends to dry out and crack, due to high temperatures, vibration and mechanical stresses caused by starting. These failures occur at the point where the coil leaves the slots, creating short circuits in the coils and possible failure from coils to ground. The cracks provide lodging places for dust and moisture, restrict the ventilation through the windings and create

excessive temperatures. This can be prevented by cleaning and drying the windings and giving them a coat of insulating varnish. The periods between these spraying treatments vary from six months to three years, depending upon operating conditions.

In checking motor equipment, care should be taken to include the checking of air gaps. The size of air gap has an important bearing on the power factor of the motor, due to the fact that the magnetizing current will be increased with resultant lower power factor. Good maintenance procedure calls for the periodic checking of air gaps with a feeler gage to insure against low bearings. Measurements should be made on the pulley or gear-end of the motor, and taken approximately 90 degrees apart. It is well to keep a record of these finds for future reference, as a comparison of readings from time to time will permit the detection of a bearing going down.

Commutators and slip rings are important parts of the motor and require varying amounts of attention. High mica is a common source of trouble on commutator surfaces and can easily be removed with the aid of a hack saw blade. When mica is under cut, care should be taken to keep the slots between commutator bars clean, or short circuits may develop. A good clean smooth surface must be maintained on commutators and slip rings, if satisfactory operation is to be obtained. This can best be done by the use of hand stones. Or, if the commutator or slip rings are badly pitted or grooved, it may be necessary to use a power-driven grinder,

As the main line current flows from the course of supply to the armature windings through the brushes and commutator, it is important that these two parts be kept in good operating order. Brushes should be removed from their holders at least once a month, and their surfaces as well as the inside of the holders wiped with a cloth to remove any accumulation of dirt. It has been found by test that brush pressure cannot be determined with any degree of accuracy by hand. Good contact between brushes and commutator or collector ring surfaces can only be obtained by correct brush pressure. This can be best determined by the use of a small spring scale. The brush manufacturers' recommendations for brush pressure should be closely adhered to where possible. Self-lubricating brushes should be used. In all cases, brushes should be replaced when they have worn to within $\frac{1}{8}$ inch of useful brush length.

Insulation Resistance

In electrical equipment, insulation plays an important part. If insulation breakdowns are prevented, a large part of the maintenance job is done. Moisture, oil and dirt are three common enemies of insulation. There are others, such as graphite, and acids, but these are associated chiefly with local conditions. Oil, moisture and dirt on the other hand are to a greater or less degree present in every installation. Insulation resistance may be measured in several ways, but megohm meters are probably the most widely used.

The resistance of the circuit to ground includes the motor end of the line switch, wiring, control equipment, wiring to motor and motor winding. The resistance can be measured with a megohm meter by connecting one test lead to ground and the other to the load side of the line switch.

In the case of a starting compensator, it is placed in the starting position and a reading taken; then it is thrown over to the running position and another reading taken. This test is made with the oil in place. Any part of the circuit found with a resistance of one megohm or less should be given immediate attention to locate the weak spot and rectify the trouble. It is recommended that the insulation resistance for rotating machines should be at least equal to that obtained by the formula where:

$$\text{Insulation resistance in megohms} = \frac{\text{Voltage at Terminal}}{\text{Rating in KVA} + 1000}$$

It can be readily calculated that insulation resistance in the average water works equipment is relatively small. It is therefore recommended that a minimum standard of $2\frac{1}{2}$ megohms be maintained.

Bearings

Bearings are divided into two classifications, namely, sleeve bearings and ball or roller bearings. The most generally used bearing is the sleeve type. During recent years the simpler sleeve type bearings have been superseded by the sealed sleeve type, which requires very little attention, since the oil does not become contaminated and oil leakage is negligible.

Ball or roller bearings offer less friction resistance in starting, although the running friction is practically the same for both types.

Sleeve bearing design in general is based on the fluid theory of

lubrication developed about fifty years ago. The theory being that the oil, because of its adhesion to the shaft and because of its viscosity or resistance to flow, is dragged along by the rotation of the shaft, so as to form a wedge shaped film between the shaft and the bearing. This action sets up a pressure in the oil, which in turn supports the load on the bearing. The film thus completely separates the bearing surfaces, so that there is no metal to metal contact. There is, therefore, no bearing wear when running. The thickness of this oil film has been carefully measured and found to be between .002 and .003 of an inch at normal speed.

Due to friction losses in starting and the difficulty in developing sealing arrangements to keep the oil within the bearing housing, the ball or roller bearing was designed. The ball and roller bearing are grease lubricated and offer a solution to the problem of retaining the lubricant in the proper place.

Survey of Motor Failures

A recent survey of a large manufacturing plant showed that 35 per cent of induction motor failures were attributed to bearing trouble. This follows because failure of a bearing allows the motor to rub against the stator, changes the air gap and creates heating.

The bearings of all electrical equipment should therefore be carefully inspected at scheduled periodic intervals in order to secure maximum life. The frequency of inspection, including addition of oil, changing the oil and bearing wear, is best determined by a study of the particular operating conditions. Old types of sleeve bearings require frequent inspection and oil changes. The newer sealed type sleeve bearing requires very little attention, since the oil does not become contaminated and there is very little leakage. Maintenance of the correct oil level is frequently the only upkeep required on this type of bearing.

The safe temperature rise for a bearing is considered to be 40°C. rise above the room ambient. At this temperature, a bearing feels only comfortably warm to the bare hand. Warm bearings may be due to any of the following causes: no oil, failure of oil ring to revolve with the shaft, rough bearing surface, dirty or poor oil, bearing caps too tight, end thrust, or improper leveling.

If a bearing becomes hot, first reduce the load if possible and feed lubricants freely, loosening nuts on bearing caps. If relief is not afforded, shut down—keeping the machine running slowly until shaft

is cool, in order that the bearing will not "freeze." In all cases, renew the oil before starting again.

The essential functions which the lubricant in a ball bearing should perform, are: first, to protect the surface of balls and races from rust or corrosion; second, to assist in the exclusion of dirt and water by forming a supplementary seal; and third, to prevent friction between balls and retainers. It is necessary, therefore, that the lubricant be free from acids, alkali or sulfur. An ideal lubricant is a pure soda soap mineral grease, with a consistency stiff enough not to churn and yet soft enough not to dry out.

Due to the fact that ball or roller bearings are completely enclosed, it is difficult to determine the amount of grease they require. Housings should be only one-third to one-half full and the grease level just above the top of the lowest ball. Over heating is more often caused by too much grease than too little. If the housing is full, there is a tendency for soft grease to churn and generate heat due to internal friction—this causes milling and permits the grease to leak out. The proper grease level is most easily obtained by removing the end cap. Ball bearings need not be greased more than once a year, except on unusual applications. If bearings are greased too often, the housing will fill up and heating occurs.

Bearings may be cleaned without dismounting by flushing, hot, light oil (160–180°F.) through the housing. If the hardened grease cannot be readily softened by this method, it will be necessary to remove the bearing and dissolve the grease in a vessel of solvent.

Control Equipment

There can scarcely be any class of electric motor application that requires the varied control system that goes with electric pumping. The large percentage of the causes for motors being out of service are chargeable to faulty control equipment. Consequently, if the continuity of service is to be maintained, starters and controllers must be given regular attention. Electric-driven equipment may be started, stopped and controlled by devices that are accurate and rapid in operation, compact and durable in construction. Fractional horsepower and motors up to and including seven and one-half horsepower are frequently started by safety switches directly connected to the source of supply. On motors larger than seven and one-half horsepower, the most common type of starter used is the automatic across-the-line type. These starters employ several

methods of limiting starting current to a reasonable value, namely:

1. By using a resistor to reduce the voltage applied to the terminals of the primary windings.
2. By using auto-transformers to reduce the voltage applied to the terminals of the primary windings.
3. By changing the connections of the three-phase windings from delta to star, thus reducing the voltage applied to each winding. (This method can be used only when both terminals of each phase winding are brought out, and when a comparatively low starting torque is required.)

Automatic across-the-line starters are operated in several different ways: push button, float switches, pressure switches, time clocks, thermostats and by interlocking with other mechanical devices. The push button type of control is the one most commonly used. Stations may include one or more buttons of the momentary contact type, or the buttons may be of the snap type. These buttons have relatively light operating mechanism and therefore are limited to current carrying capacities.

Motor operating voltages are generally higher than 250 volts and in such cases control transformers are used to reduce the voltage for control circuits to 125 volts, eliminating danger of injury to operators and reducing the possibilities of ground trouble in the wiring.

One of the chief troubles experienced with across-the-line starters is heavy arcing at contacts. To keep this at a minimum, arc chutes and blow-out coils should be kept in good condition. Excessive arcing of contacts may cause short circuits, rapid burning and frequent renewal of the contacts, overheating that will destroy contact pressure spring tension and freezing of contacts closed. Switch contacts must be maintained in good condition to prevent their surfaces from becoming rough due to arcing or poor contact. They should be replaced or their surfaces dressed, before they become too badly pitted. Light dressing can be done by holding the switch closed and drawing emery paper between the contacts, until they meet for the full width of their faces.

Contacts may be properly aligned by holding them closed, then tightening the screw or bolt fastening them in place. They should be adjusted so that all make and break at the same instant. Contact pressure springs must be in good condition. All bearing parts

must work freely, so that the contacts make and break with a snappy action. The cross-bar and space between contacts must be kept clean of all carbon and copper dirt, to prevent short circuits.

When arcing tips are provided on switches, they must be kept in good condition to take the burning when opening and closing to protect the main contacts. If the armature of an alternating current magnet is noisy and vibrates, it indicates that it is not sealing properly, or that the shading oil may be broken. Oil must be used sparingly, if at all, on contactor bearings, as too much oil causes gumming and sticking.

Tripping contacts should be inspected when a magnet burns out, as sometimes sufficient current may have passed through them, so as to weld them together. If this condition is found and not corrected, the starter will fail to trip when needed and may burn out a motor or damage equipment.

Drum type controllers give little trouble when contact surfaces are kept clean and slightly lubricated with vaseline or other paste made for this purpose.

The care of compensator contacts is much the same as those for contactor switches. The contacts must be properly aligned, so that all make and break together. This is best accomplished by not using new contacts with old ones that have been worn considerably. It is good practice to use only new contacts on the running side of the compensator, to insure good connections. The old ones taken off can be filed and dressed for use on the starting side. In most cases it is recommended that the oil in compensators be replaced once per year, if the starting duty is hard, or oil shows signs of being dirty or carbonized. The operating mechanism should be checked for free operation. The action of over-load and under-voltage release should be checked and adjusted if necessary. Examine all terminal studs and nuts for looseness and make sure that all connections are tight. Any discoloring of contactor metal indicates heating and may be due to over-loading or loose connections.

Copper contacts of circuit breakers are bound to oxidize and this is particularly true where the oil circuit breaker is not operated over a period of time. The oxidization is soon noted by the accumulation of heat. Whenever possible it is advisable to open and close circuit breakers for trial operation. This operation will also help to eliminate the oxidizing of copper contacts.

Transformers

Trouble free operation of transformers depends upon the care with which they are installed and maintained quite as much as upon the skill used in designing and manufacturing them.

Since self-cooled transformers depend entirely on the surrounding air to carry away the heat, it is necessary that they be provided with adequate ventilation. They should be spaced so that there will be 20 to 30 in. of space between units and adjacent walls in order to permit free circulation of air between them. Largely due to the absence of moving parts, transformers require, or can get along with less maintenance attention than many other kinds of equipment. However, to minimize the possibilities of breakdown, certain points should be checked at regular intervals. The conditions of the insulation and of the insulating oil are the two most important points. Bushings and their insulation resistance together with that of the transformer windings should be tested at least once a year.

In checking transformer insulation, the installation should be checked as a unit, that is a bank of transformers with all appurtenances attached. If the reading is greater than one megohm per 1000 volts in the entire unit, there is no need for worry. However, should a lower reading be obtained, it will be necessary to check the component parts to locate the low reading.

Power transformers should be taken out of service and thoroughly gone over at least once a year. Such an inspection should include checking of all bushings and bus insulations, buswork, oil level gages, fittings, disconnect switch hinges and pins, and the necessary greasing and oiling of parts. The gaskets on the top covers, manhole covers and bushing flanges should be inspected for leaks at least twice a year.

Thermometers on transformers should be maintained in good order at all times. Close observation should be kept of oil temperatures to guard against excessive heating. A safe operating temperature for self-cooled transformers is about 80°C., and about 65°C. for water-cooled units.

Insulating oil in transformers becomes dirty because of the water and dirt introduced during "breathing" and from the formation of sludge, which is caused by heating the oil over long periods in the presence of air. Several methods of purifying oil are in use. One

involves the use of the filter press; another uses a centrifuge; the third makes use of a chemical process.

When taking transformer oil samples for dielectric tests, care should be exercised in cleaning the container, which should preferably be a large-mouthed glass bottle of 16 or 32 oz. capacity, with a cork stopper. Samples should be drawn from the sampling valves at top, center and bottom of transformer tank. Sufficient oil should be drawn off to insure getting samples that are representative of the oil in the transformer tank, rather than in the sampling pipe.

It is also important that the tests be conducted properly. Before the standard oil-testing cup is used, it should be thoroughly cleaned and rinsed with oil from the sample. After the test cup has been filled, it should be allowed to stand for a few minutes, before making the test. Five breakdown tests should be made on each filling, and the cup emptied and refilled from the original sample. The average dielectric strength of the oil should be at least 20 k.v. If values less than this are found, the oil should be refiltered.

Most transformers are built to withstand considerable over-load for short periods with very little loss in life. However, large over-loads carried for long periods are likely to result in marked shortening of the life of the transformer.

Transformer coils may be cleaned by filling them with a mixture of equal parts of water and hydrochloric acid, which will have a specific gravity of 1.10. After this solution remains in the coils about one hour, it should be thoroughly flushed out with plenty of clean cold water.

Instruments

The instruments most commonly found in the water works plants are the ammeter and voltmeter (designed for use on a.c. or d.c. circuits), single-phase and polyphase wattmeters, power factor meters, demand meters, watthour meters and megohmn meters for checking insulation resistance.

The maintenance man can and should use instruments wherever possible. There are innumerable opportunities. Some of the frequent applications are as follows:

1. To check loading of motor or generators.
2. To measure current in feeders and branch circuits.
3. To determine voltage applied to apparatus.

4. To determine insulation resistance.
5. To check unusual conditions.

Instruments can show their worth in actual dollars saved, resulting from such tests.

Indicating and graphic meters should be checked about three or four times a year, recording meters should be checked about twice a year and where extreme accuracy is desired, they should be recalibrated once a year.

The methods of calibrating both a.c. and d.c. watthour meters are carefully outlined by the makers and should be followed without deviation.

Calibrations of indicating types of voltmeters, ammeters, and wattmeters are hardly practicable in the average plant. Have them done by the manufacturer or by a service laboratory.

Checking Meters

In checking meters, the following items will greatly aid in maintaining meter accuracy and eliminate more serious trouble:

1. Replace broken or loose glass to prevent dust collecting on inside meters.
2. Keep all connections clean and tight.
3. Keep exterior cases and parts clean.
4. Keep meters free from dust, oil and moisture.
5. Never oil any bearings or moving parts of meters.

The protection relay is an electrical instrument used in conjunction with meters, starters and control equipment. It is accurate, sensitive, rugged and reliable in construction, and interposed between the main circuit and the circuit breaker in such a manner that any abnormal condition in the circuit acts on the relay, which in turn, causes other apparatus, such as circuit breakers, to function and relieve or protect the circuit and apparatus.

Unless electric power equipment is protected, no amount of inspection or maintenance will prevent failures.

There are three principal types of relays used; of these the induction type has become the most popular. However, the most commonly used and best known to most of us is the thermal overload relay. This relay depends upon the heating of a bi-metallic strip for its tripping action.

As most motors draw six to eight times normal running current when starting, it is necessary that main line fuses, or circuit breakers

be three times motor rating. These afford no overload protection to the motor below 300 per cent. It is therefore necessary to provide some protection to the motor winding within a reasonable value of full load current. Relays are used for this purpose and in most cases are adjusted to operate at 125 per cent of full load current. This setting allows for 10 to 15 per cent motor overload for short periods of time.

If relays are properly handled, no special trouble should be encountered. Experience indicates that with proper attention and care, relays should not give any more trouble than indicating instruments or watthour meters installed in similar places.

Maintenance work for all equipment, if organized on the basis of correcting as completely as practicable the depreciation caused by electrical, mechanical and conditioned agencies, will without doubt increase the use and life of plant equipment, and assure continuity of service.

A Simple Method of Testing Centrifugal Pumps

By Homer E. Beckwith

UNTIL twenty years ago the steam-driven displacement type of pump was in general use, but since then a great change has taken place, particularly in the small and medium sized plants, and today the great majority of pumping stations are equipped with electrically-driven centrifugal pumps, with an occasional diesel-driven or turbine-driven centrifugal installation. The modern centrifugal pump is designed to work under rather rigidly fixed conditions and any appreciable variation from these conditions is accompanied by a falling off in efficiency.

Unfortunately, the non-technical water works operator who got his early practical experience with the old displacement type of pump has not always become sufficiently acquainted with the characteristics of the centrifugal pump. Only too often the only demand made on a centrifugal pump is that it pump water. No attention is paid to the efficiency with which it does its work. In fact, the average water works man is not acquainted with any simple method of determining this efficiency. It is the purpose of this article to point out the conditions which may be expected to cause low operating efficiency, and to outline a simple method for testing the wire to water efficiency which gives results as close as is necessary in practical water works operation.

As a youngster I used to tie a chestnut on the end of a string and whirl it around my head until I had imparted to it the force necessary to take it flying through the air at high speed. You did it too. The principle of building up velocity in that chestnut by whirling it about the head is the same principle which is used in the design of a centrifugal pump. The water which enters the pump through

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the suction inlet is seized by the rotating vanes of the impeller and spun until the water is rotating at terrific velocity. Since pressure and not velocity is desired, the pump is so designed that by gradually slowing down this velocity in the casing of the pump, the energy stored up in this rapidly moving water is almost entirely changed to pressure. The speed of the chestnut rests upon two factors—the length of the string and the number of revolutions made within a specified period of time. The speed, and hence the resulting pressure, imparted to water by a centrifugal pump also rests upon the same two factors—the diameter of the impeller and the number of revolutions per minute which the impeller makes.

There are, of course, practical limits to both the speed and the diameter so that it is not always possible to secure the full desired

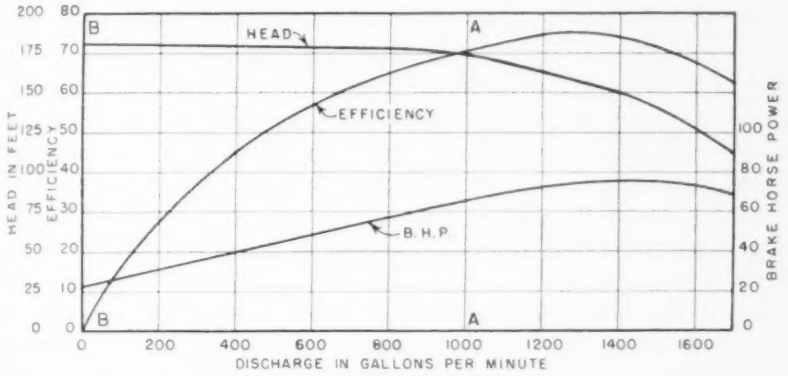


FIGURE 1

pressure with one pump. The water is then passed through two or more pumps in series and each pump raises the pressure part of the total desired amount. Sometimes these two or more pumps are built in one pump case, in which instance each pump is called a "stage." As electrically driven centrifugal pumps operate at fixed speeds, there is always one head under which a pump will operate most efficiently. Right here it will not hurt to repeat that any material deviation from this condition will result in decreased efficiency.

At this point it may be well to refer to fig. 1, a typical centrifugal pump curve which will be used for illustrating this paper. Similar curves are available from the manufacturer for all medium sized and large pumps. On small pumps it is not customary to furnish performance curves.

It will be noted from an inspection of fig. 1 that the greatest efficiency (about 75 per cent) is secured when the head is about 155 ft. and the discharge rate is about 1,300 gallons per minute. The reader will also note that as the head is materially increased or decreased there is a large change in the pumping rate and a considerable drop in efficiency. A great deal has been done in the effort to widen out the "peak" of the efficiency curve into a "plateau" so as to give high efficiencies under a wider range of operating conditions. Considerable progress has been made in this direction.

Effect of Friction Loss

Let us see what happens when we forget to include friction loss when figuring the total head against which the pump must operate. If we have figured on the pump whose curve we have, and if we are pumping through two miles of 16-inch main, the friction loss will add about 18 ft. to the pumping head, making it 173 ft. (line A-A). At this head the pumping rate will drop to 1,000 gal. per min. and the efficiency to 70 per cent. Furthermore, the pump is operating on a very critical part of the curve where a slight increase in pumping head (caused by tuberculation in the main or by any other factor) would incur a precipitate drop in both the efficiency and the pumping rate. The author has known of such cases—though not often. This also illustrates what can happen to a pump when the pumping head has been increased after installation above the head for which it was designed. As it is the nature of unlined iron and steel mains to tuberculate with a constantly rising friction loss this is an important consideration.

Let us illustrate this another way: Suppose that we are in the market for a 1,000 gal. per min. pump operating against a total head of 173 ft., and the pump whose curve we have been using has been submitted for consideration—and it might be, though the author would not consider this pump a good "buy" to operate under these conditions. In the first place it will be noted that the efficiency of 70 per cent is much below the maximum efficiency of 75 per cent. But even more important, perhaps, is the fact that the pump at a head of 173 ft. is operating under critical head conditions. An increase of only about 8 ft. or less than 5 per cent in the pumping head would bring the head to the maximum which the pump can create—in other words to the "cut off" point. This means that an increase in the head of 8 ft. (line B-B) (about $3\frac{1}{2}$ pounds) would

decrease the pumping rate from 1,000 gal. per min. to 0 gal. per min. Moreover an increase of only 3 ft. in head would cause a drop of 200 gal. per min. in the pumping rate. On the other hand, when we are working in the most efficient range of the pump a change of 3 ft. in the head would cause a variation of only 30 to 40 gal. per min. in the pumping rate. And the efficiency is practically unaffected. It follows, therefore, that one should buy a pump within the range where the efficiency curve is as *flat* as possible and the head curve is as *steep* as possible. In this connection a word of warning may not be amiss. By making the vertical scale of the curve less than is customary, a much flatter *appearing* efficiency curve can be secured. So in comparing the performance curves of pumps be sure that they are plotted on comparable scales. I have known curves with reduced vertical scales to be submitted where I felt sure that the scale was deliberately reduced with the purpose of deception.

Inefficiency of Salvaged Equipment

Only too often in the revamping of a plant, pennywise efforts are made to salvage as much of the old equipment as possible. It is assumed that if the old pump will handle 1,300 gal. per min. against 155 ft. of head, it should have no trouble pumping the same amount from the river to the settling basin against a head of only 40 or 50 ft. This is so. In fact, if we look at the curve we find that it will pump much more than 1,300 gal. per min. at the lower head. The curve does not go out that far, but it goes far enough to show what would happen—not only to the pumping rate but to the efficiency as well. The pumping rate goes up but the efficiency goes down—way down. Reducing the head has a tendency to cause a pump to run away much as an automobile would run away down hill when the going becomes easier if the throttle were not closed to compensate for the decreased demand for power. This running away of the pump sometimes overloads the motor so that it runs hot. To prevent this, the head is often artificially increased by closing a valve on the outlet side of the pump. This decreases the load on the motor and brings the pumping rate back to normal. But it burns up a great deal of power needlessly as the closed valve destroys part of the head generated by the pump and only part of the work actually performed is effective. The writer has known of installations such as this where the installation of a new pump saved in one year more than enough power to pay the entire cost of the new pump and motor.

But it is not always necessary to buy a new pump just because the head has been reduced. If we will get back to the chestnut on the string we will find that we can reduce the speed of the chestnut by reducing the length of the string while at the same time keeping the number of revolutions constant. In the same manner, we can cut down the pressure generated by a constant speed centrifugal pump by reducing the diameter of the runner. If the reduction in head is moderate, the manufacturer can advise you how much will have to be machined off the outside of the present impeller so that it will pump efficiently, or at a slight expense he will furnish a new impeller for the changed conditions.

It is sometimes, but not always, possible to secure a larger impeller to efficiently handle increased heads, but in this case the motor is likely to be overloaded.

Another way to increase the speed of the chestnut would be to keep the length of the string constant and to increase the number of revolutions. It follows that if we increase the revolutions of any centrifugal pump we will increase the head which that pump will generate. This explains why a certain pump tested last fall gave a wire to water efficiency of only 40 per cent. This pump was designed for use with a gasoline motor and to operate under the existing head conditions at a speed of 1,400 r.p.m. Eventually electric power became available and the pump was connected to an electric motor and the speed increased to 1,800 r.p.m. This, of course increased the head generated by the pump, with the result that it was working against only a portion of its design head and the efficiency was, consequently, very low.

A somewhat similar condition was found several years ago when a 5 million gal. per day installation designed to work against a head of 100 lb. was found to have been connected in series to a 5 m.g.d. pump designed to pump against 50 lb. pressure. This gave an installation with a design head of 150 lb., but the actual head was still about 100 lb. The output was thereby increased to approximately 6 m.g.d. but the efficiency decreased to the point where it was only slightly above 40 per cent. New and properly designed equipment brought the wire to water efficiency up to about 75 per cent.

It can be readily seen from the above that the chances of buying a suitable pump from the junk man are just about nil. It might be "as good as new" for the conditions for which it was designed and

TABLE 1

Gallons of water delivered per kilowatt hour against various heads on theoretical assumption that pump and motor are 100 per cent efficient

H = head in feet. G = gallons per kilowatt hour

H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G
1	318,200	51	6,240	101	3,151	151	2,108	201	1,583	251	1,268	301	1,058	351	907	401	794	451	706
2	159,100	52	6,120	102	3,120	152	2,094	202	1,575	252	1,263	302	1,054	352	904	402	792	452	704
3	106,100	53	6,005	103	3,090	153	2,080	203	1,567	253	1,258	303	1,051	353	902	403	790	453	703
4	79,560	54	5,894	104	3,060	154	2,067	204	1,560	254	1,253	304	1,047	354	899	404	788	454	701
5	63,650	55	5,786	105	3,031	155	2,053	205	1,552	255	1,248	305	1,044	355	897	405	786	455	700
6	53,040	56	5,683	106	3,002	156	2,040	206	1,545	256	1,243	306	1,040	356	894	406	784	456	698
7	45,460	57	5,583	107	2,974	157	2,027	207	1,537	257	1,239	307	1,037	357	892	407	782	457	697
8	39,780	58	5,487	108	2,947	158	2,014	208	1,530	258	1,234	308	1,033	358	889	408	780	458	695
9	35,360	59	5,394	109	2,920	159	2,002	209	1,523	259	1,229	309	1,030	359	887	409	778	459	694
10	31,830	60	5,304	110	2,893	160	1,989	210	1,516	260	1,224	310	1,027	360	884	410	776	460	692
11	28,930	61	5,217	111	2,867	161	1,977	211	1,508	261	1,220	311	1,024	361	882	411	775	461	691
12	26,520	62	5,133	112	2,842	162	1,965	212	1,501	262	1,215	312	1,020	362	879	412	773	462	689
13	24,480	63	5,051	113	2,816	163	1,952	213	1,494	263	1,211	313	1,017	363	877	413	771	463	687
14	22,730	64	4,972	114	2,794	164	1,940	214	1,487	264	1,206	314	1,014	364	875	414	769	464	686
15	21,220	65	4,896	115	2,766	165	1,929	215	1,480	265	1,202	315	1,011	365	873	415	767	465	685
16	19,890	66	4,822	116	2,744	166	1,917	216	1,474	266	1,197	316	1,007	366	870	416	765	466	683
17	18,720	67	4,750	117	2,720	167	1,906	217	1,467	267	1,193	317	1,004	367	868	417	763	467	682
18	17,680	68	4,680	118	2,697	168	1,894	218	1,460	268	1,188	318	1,001	368	865	418	761	468	680
19	16,750	69	4,611	119	2,674	169	1,883	219	1,453	269	1,184	319	998	369	863	419	760	469	679
20	15,910	70	4,547	120	2,652	170	1,872	220	1,447	270	1,179	320	995	370	860	420	758	470	677
21	15,150	71	4,482	121	2,630	171	1,861	221	1,440	271	1,175	321	992	371	858	421	756	471	676
22	14,470	72	4,420	122	2,609	172	1,851	222	1,434	272	1,170	322	989	372	856	422	754	472	675
23	13,830	73	4,360	123	2,588	173	1,840	223	1,427	273	1,168	323	986	373	854	423	753	473	674
24	13,260	74	4,301	124	2,567	174	1,829	224	1,421	274	1,162	324	982	374	851	424	751	474	672
25	12,730	75	4,243	125	2,546	175	1,819	225	1,414	275	1,158	325	979	375	849	425	749	475	671
26	12,240	76	4,188	126	2,526	176	1,809	226	1,408	276	1,154	326	976	376	847	426	747	476	669
27	11,790	77	4,133	127	2,506	177	1,798	227	1,402	277	1,150	327	973	377	845	427	746	477	668
28	11,370	78	4,080	128	2,486	178	1,788	228	1,396	278	1,146	328	970	378	842	428	744	478	666
29	10,970	79	4,028	129	2,467	179	1,778	229	1,390	279	1,142	329	968	379	840	429	742	479	665
30	10,610	80	3,978	130	2,448	180	1,768	230	1,384	280	1,137	330	965	380	838	430	740	480	663
31	10,270	81	3,929	131	2,429	181	1,758	231	1,378	281	1,133	331	962	381	836	431	739	481	662
32	9,945	82	3,882	132	2,411	182	1,749	232	1,372	282	1,129	332	959	382	833	432	737	482	660
33	9,644	83	3,834	133	2,393	183	1,739	233	1,366	283	1,125	333	956	383	831	433	736	483	659
34	9,360	84	3,789	134	2,375	184	1,729	234	1,360	284	1,121	334	953	384	829	434	734	484	658
35	9,093	85	3,744	135	2,358	185	1,720	235	1,354	285	1,117	335	950	385	827	435	732	485	657
36	8,840	86	3,701	136	2,340	186	1,711	236	1,349	286	1,113	336	947	386	825	436	730	486	655
37	8,601	87	3,658	137	2,323	187	1,702	237	1,343	287	1,109	337	945	387	823	437	729	487	654
38	8,375	88	3,617	138	2,306	188	1,693	238	1,337	288	1,105	338	942	388	820	438	727	488	652
39	8,160	89	3,576	139	2,292	189	1,684	239	1,332	289	1,102	339	939	389	818	439	725	489	651
40	7,956	90	3,536	140	2,274	190	1,675	240	1,326	290	1,098	340	936	390	816	440	723	490	650
41	7,762	91	3,497	141	2,257	191	1,666	241	1,320	291	1,094	341	934	391	814	441	722	491	649
42	7,577	92	3,458	142	2,241	192	1,658	242	1,315	292	1,090	342	931	392	812	442	720	492	647
43	7,401	93	3,422	143	2,225	193	1,649	243	1,310	293	1,087	343	929	393	810	443	719	493	646
44	7,233	94	3,386	144	2,210	194	1,640	244	1,304	294	1,083	344	926	394	807	444	717	494	644
45	7,072	95	3,350	145	2,195	195	1,632	245	1,299	295	1,079	345	923	395	805	445	716	495	643
46	6,916	96	3,315	146	2,180	196	1,624	246	1,294	296	1,075	346	920	396	804	446	714	496	642
47	6,771	97	3,281	147	2,165	197	1,615	247	1,288	297	1,072	347	918	397	802	447	712	497	641
48	6,630	98	3,248	148	2,150	198	1,608	248	1,284	298	1,068	348	915	398	800	448	710	498	639
49	6,495	99	3,215	149	2,136	199	1,600	249	1,278	299	1,065	349	913	399	798	449	709	499	638
50	6,365	100	3,183	150	2,122	200	1,592	250	1,273	300	1,061	350	910	400	796	450	707	500	636

yet be absolutely worthless under any other conditions. In fact, it would probably be a most expensive liability. Yet pumps have been bought from junk men.

So far, we have been discussing equipment which has been working under conditions which made it impossible to give a creditable showing. A mere inspection of the conditions and a knowledge of the design limitations would make it evident that satisfactory performance under these conditions could not be secured. However, there are occasions where after installation things happen to properly selected pumps which will cut the efficiency of the equipment. There was, for instance, the time when we found a water snake wrapped around the shaft with the result that the inlet ports were partially cut off and the suction lift increased way beyond the 15 ft. maximum for best performance. In another and similar situation blocks of wood were found jammed in the ports. Then there was the time that low efficiency was caused by the blowing of the gasket of a multiple stage pump and the water was short circuiting back from a higher stage to a lower stage. One of our engineers once reported that an efficiency of 20 per cent was caused by the impeller slipping on the shaft.

Two interesting conditions have been found by the author which have no reference to the actual efficiency of the pumps but which were determined as the result of making efficiency tests. In one instance, where the meter through which power was purchased was used to measure the power input, it was found that an apparent low efficiency was caused by this meter being set 20 per cent high. In another instance, a pump was discharging into a closed distribution system. On the basis of the water *actually discharged* into the system over a 24-hour period the pump had an efficiency of only 8 per cent. Had a standpipe or reservoir been floating on this system, the same amount of water could have been pumped with about one-eighth the amount of power which was actually used.

Enough has been said, it seems, to emphasize the importance of keeping a check upon all centrifugal pumping equipment to be sure that it is working in a satisfactory manner. The writer has worked out a simple method for making these tests which he has been using for some years with satisfactory results. At one foot of head and 100 per cent efficiency of both pump and motor it would be theoretically possible to pump 318,200 gallons of water with one kw.hr. To determine this theoretical value for any other head, simply divide

318,200 by the required head. For instance, the value at 159 ft. would be 318,200/159 or 2,002 gal. per kw.hr. To determine the wire to water efficiency of an installation it is only necessary to divide the actual pumpage per kw.hr. by the theoretical value for the pumping head as determined above. A rough check can be made by dividing the month's pumpage in gallons by the kw.hr. consumed. This gives the gallons actually pumped per kw.hr. With the pump running, determine the total head in feet (including suction) against which the pump works. Divide 318,200 gal. by this total head to determine the theoretical 100 per cent pumpage per kw.hr. Next divide the actual gal. per kw.hr. by the theoretical gal. per kw.hr. to secure the wire to water efficiency. To illustrate:

Assume a monthly pumpage of 32,640,000 gallons and a monthly power consumption of 30,200 kw.hr. The total head is 220 ft. Dividing 32,640,000 by 30,200 gives an actual pumpage of 1,081 gallons per kw.hr. Dividing 318,200 by 220 gives a theoretical value of 1,447 gal. per kw.hr. $1,081 \div 1,477 = 74.7$ per cent overall efficiency.

Accurate Method of Testing

A more accurate method of making the tests is to measure the power input for an hour, or other convenient period of time. During this period measure the output of the pump with any suitable main line meter. Keep a close record also of the discharge pressure and of the suction. The integrations on most electric meters in pumping stations cannot be read closely enough for short tests. However, the power company will furnish the number of watts consumed for each revolution of the disk, and by counting its revolutions for ten or twenty minutes the rate of power input can be closely ascertained. Or the power company might measure the power by means of special equipment. Where more than one pump is taking power through the master meter at the same time, this latter method is the only feasible one.

The total head in feet must first be secured. If the pressure gage reads in pounds, transfer the pressure to feet by multiplying the pounds of pressure by 2.31. The suction will probably be expressed in inches of mercury. Change this to feet of water by multiplying by 1.13. Also measure the vertical distance between the center of the pressure gage and the point of suction measurement. The total head then becomes:

Discharge pressure, in feet
Suction, in feet
Vertical distance pressure gage is above point of suction measurement, feet

Velocity head has been ignored, as it is a small factor for the relatively high heads which usually exist in water works operation, but it may be added if desired.

If water is delivered to the pump under pressure, then the pump works against a head equal to the difference between the discharge pressure and the inlet pressure.

From the data secured during the test, determine the gallons delivered per kilowatt hour. As before, divide this by the theoretical value for the head against which the pump worked. This gives the overall wire to water efficiency of the installation.

As an example, let us assume an installation where we secured the following test data:

Kw. input to motor	90.0	
Rate of discharge	51,840 gal. per hr.	
Number of gallons delivered per kw.hr.	572	
Pressure	146 lb. or 337 ft.	
Suction	15 in. or 17 ft.	
Difference in gage elevation	1 ft.	1 ft.
Total head		355 ft.
Theoretical discharge at 335 ft. head 318,200/355		897 gal.
Overall efficiency	572/897 = 64 per cent	

Provided a suction gage is not available, an approximation may be secured by measuring the vertical distance from the level of water in the clear well to the center of the pressure gage, adding to this measured distance about two feet for loss in bends, etc.

Having shown the desirability of frequent tests and a simple method for making them, it may now be interesting to discuss what these tests may be expected to show. In the first place, there have been great increases in the attainable efficiencies of centrifugal pumps within the past few years. Those of modern design may be expected to give up to the overall or "wire to water" efficiencies shown in table 2. It will be noted that the larger the pump the higher the efficiencies. There will be variations from these figures depending upon the head and other conditions. They are submitted only for the purpose of giving something with which to compare the efficiencies of existing installations. This is important,

because it will often be found that older equipment may have retained its original efficiency and yet be so inefficient in comparison with equipment now available that it is decidedly not economical to keep it in operation. It will be worth while to check the present efficiency of equipment over ten years old to determine how great a reduction in power consumption can be secured by the substitution of more efficient modern pumps. You may be surprised. If an old 1,000 gal. per min. pump operating at an efficiency of 57 per cent is replaced with a new pump giving an overall efficiency of 73 per cent the same amount of water could be pumped with 22 per cent less power. This means that both the demand rate and the power consumption through each step of the rate would be decreased 22 per cent. Such a reduction might be enough to pay for the new installation in about one year's time. In order to get the gallons per

TABLE 2

Wire to Water Efficiencies

CAPACITY	EFFICIENCIES	CAPACITY	EFFICIENCIES
gal./min.	*per cent*	*gal./min.*	*per cent*
200	58	1500	75
400	63	3000	80
600	68	5000	82
800	71	Over 5000	85
1000	73		

kw.hr. to be expected at any head at any efficiency it is necessary to determine only the theoretical gallons per kw.hr. for that head and then to multiply this theoretical value by the expected efficiency. If the total pumpage in gallons is then divided by this expected pumpage per kw.hr. the power consumption to be anticipated from the new installation will be secured. Similarly it is possible to determine the anticipated demand rate, which is often as important as the total kw.hr. consumption in determining the power bill.

Messrs. Marshall and Rawlins of the Charlotte, N. C., water works department organization have recorded how power costs were reduced in that city. These power costs, which had been running about $16 per million gallons have been cut to about $7.50 per million gallons, the cut being the result of two definite and distinct improvements. In the first place the pumping main was paralleled with a new line, thus reducing the friction loss to a fraction of its former amount. This cut the power cost from $16 to $12 per mil-

lion gallons. Then, the old inefficient pumping units were replaced with modern efficient equipment, which further reduced the cost to $7.50 per million gallons. There are many other plants in the country waiting for managers of Mr. Marshall's foresight to cut operating costs. If there be any doubt that such places exist, or that similar savings have not frequently been made, an examination of reports on pumps tested by the writer's company should prove conclusive evidence that they do exist and that unexpectedly large savings are possible.

In conclusion, the author wishes to thank the Gould Pump Co., the DeLaval Steam Turbine Co., and the Worthington Pump and Machinery Corp. for their help in preparing this article.

The Water Department as an Independent Utility

By D. C. Egbert

MANY municipalities are credited with being tax free or comparatively so, due to the fact that the normal municipal functions are financed entirely or partially from revenues derived from publicly owned utilities. This applies to water departments, and in some cases to other municipally owned utilities. We are primarily interested in the question of such a policy as it affects water department operation.

The proper operation of a water department requires a sound financial policy, as does the operation of any other public utility. The fact that the water department of any municipality is not subjected to the same rigid control and restrictions which are placed on similar more or less monopolistic utilities does not relieve officials of the responsibility for the proper financial plans for needed expansion of the services, and proper maintenance of the physical properties to provide pure water of a quality which is so necessary to the modern city. The financial policy should contemplate the orderly development of the department, with full consideration being given to the future needs and in accordance with a long term plan of development.

Major additions to the plant and distribution system can well be financed by revenue bonds or other bonds, to be paid from the revenues derived from the water department, but care should be exercised to prevent the water department from lending itself to the aid of subdivision developers, anxious to sell their property and influencing officials responsible for the policies of the department to expand the water distribution system beyond reasonable limits for such purposes.

In those cases where funds derived from water revenues are di-

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verted to other purposes, whether it be through an excessive rate which provides revenue beyond the needs of the department or diversion of funds needed by the department for proper maintenance and expansion, that portion of the funds so diverted ceases to be a charge for water service and becomes a tax. The question of diversion of funds, therefore, can well be considered from the angle of whether or not there is any justification for such a tax.

Basis for Taxation

The generally accepted theories of taxation are based on a levy for each individual in accordance with his ability to pay, or a charge for services rendered to a particular property, or securing revenues by the easiest method available without consideration of the equities involved. The tax placed on real and personal property and on incomes is based on the ability to pay. Special assessments are spread in accordance with the benefits derived. The diversion of funds from the revenues derived from the operation of a water department falls in the class of those taxes which are easy to collect without serious objection from the tax-payer and generally have no justification except political expediency.

The question of such a tax added to the water rates being justified on the grounds that it is based on ability to pay, can well be raised and should be thoroughly analyzed. It must be admitted that, in the normal residential consumption of water, the owner of a large home is a greater consumer of water than the owner of a small home, but any study of the water bills will also show that the revenues derived from the large home and the comparatively inexpensive home do not vary in the same proportion as the values of the homes vary. This is particularly true where water rates are on a graduated basis decreasing with consumption. Any tax added to the use of water by homes is a tax placed on one of the necessities of life and those officials who are not inclined to collect taxes the easiest way available will shout the loudest against any tax placed on such necessities. The injustice of such a tax is even more apparent when added to the water bills of business or industry. Here particularly the water consumption is no measure of the ability to pay, and any such business or industry using large amounts of water is subjected to an unfair tax.

The water rate, which is ample for the proper operation of the department, proper maintenance of plant and in accordance with a

sound financial plan based on such revenues for the financing of needed expansions and improvements, is truly a charge for service rendered. The mere fact that a part of the revenues from the water department is in reality a tax, and is comparatively easy to collect, is certainly no justification for such a tax. This method of raising revenue may be acceptable to any official who accepts the duty of his office lightly, but any honest official will oppose such taxes where inequities are so apparent as they are in this case.

The plan of development must be guided by a well defined policy in regard to the expansion of the distribution system to avoid the errors that are now so apparent in the condition which exists in the southern portion of Michigan, where thousands of lots are now tax delinquent and the possibility of any use being made of these lots is very problematical. These same lots are to a large extent provided with water mains and water service is available and maintained at the expense of the water users in the districts which have been properly developed, and at a great cost to the water departments. Even in those cases where the costs of these expansions of the distribution system are to be paid for from the proceeds of special assessments, the need for such expansions should be carefully studied and, the soundness of the development determined. Many municipalities have found, to their sorrow, that such special assessments cannot be collected, that their funds have been expended for the benefits of the subdividor or real estate speculator and that the maintenance of this system now involves an added expense to the department.

The continual search for new sources of revenue by municipalities, particularly those municipalities having tax limitations, creates a continuing pressure for the diversion of funds from the water department to the general fund. Officials responsible for the operation of water departments, desiring to operate and maintain the departments properly, will have the burden of resisting such efforts. This diversion of funds from those departments charging only a nominal rate will result in a day of reckoning with resultant disaster to the department. Excessive rates with diversion of excess revenues to the general fund can result only in inequities which any conscientious official should strenuously oppose.

Studies preparatory to the adoption of a financial policy should include a study of all past policies and the methods pursued in the past for the financing of the plant acquisition and improvements and additions thereto. With this information available a compre-

hensive study of the future needs must be made, and a long term financial policy determined to care for these needs, with provisions for servicing the existing debt of the department. There must be prepared a regular operating budget to include all items of expense other than major capital improvements. The normal operating budget together with the budget for financing of major improvements will provide for a complete budget for the water departments. This entire problem is simplified and the questions arising are clear cut when the department is set up as a utility entirely divorced from the regular city functions. Any transfer of funds from the general fund to the department, or from the department to the general fund, should be treated as a loan and repaid. Any efforts to cancel such obligation should be vigorously opposed. Under these conditions transfers can be less readily made and efforts to accomplish this reduced to a minimum.

Justification of Rates and Charges

The studies involved in determining rates should take into account the necessity for deriving revenues sufficient for the efficient operation of the department, necessary maintenance and financing of expansions in accordance with the general policy which has previously been determined. In those municipalities where the water department plant has been purchased by funds secured by a general tax levy, there is certainly some justification for some return to the general fund from the revenues of the department. The charges levied for the extensions of the distribution system should be in accordance with a well determined policy strictly adhered to, and the method of levying these charges should be in conformity with the general financial plan. Charges for service connections and other miscellaneous charges should be determined in the most equitable manner and well defined policies outlined. We are seldom privileged to form a water department as an independent utility. The greatest equity can be secured by a comprehensive study of the policies, or lack of policies, which have been in effect in the past; and then new policies, rates and charges established, contemplating the operation of the department as nearly as possible on the basis of an independent utility.

With the water department organized and functioning as an independent utility, under adequate budgetary control and distribution of costs in accordance with the budgetary divisions, it is possible to

determine the costs of the various operations and greater efficiency can be more readily obtained with resultant savings to the water consumers. There can be secured a more equitable distribution of the costs of operation of the department and the water consumers will not be paying an unfair share of the cost of other city operations.

Yearly audits and reports of the operation of the department can be made available to the water consuming public and the fairness of the rates charged can be readily shown. Reports of this nature would tend to convince the general public of the soundness of the operation of the department and make more difficult any diversion of the funds from the department.

It would appear that the officials earnestly endeavoring to provide an adequate water supply at a reasonable cost, should be interested in having the water department function as an independent utility and this should be a main objective of all officials charged with the responsibility of the operation of a water department.

The Small Water Department

By James L. Galloway

ACCORDING to statistics from the State Health Department, we have in the state 47 filter plants and 46 chlorination plants. There may be a slight change in these figures at the present time due to new construction during the past year. Of the 47 filter plants there are 8, or approximately 17 per cent, which have a rated capacity of over 6 million gallons daily. There are 3 plants which have a rated capacity of 6 m.g.d., or 6.4 per cent. This leaves 36 filter plants, or 76.6 per cent, with a rated capacity of from 4 m.g.d. down to .3 m.g.d. If we average this figure with the per cent of chlorination plants serving total populations of less than 6,000 we find that over 70 per cent of the water departments in the state very definitely come within the category of small departments.

A water department can be divided into six units, as follows:

1. The operation of the water plant with the accompanying problems of treatment and mechanical difficulty.

2. The distribution system with sub-headings of construction and maintenance of mains, system of mains, valves and hydrants, installation of services, and the installation, reading and testing of meters.

3. The office work with the accounting system, the billing, the correspondence, and ordering.

4. Public relations, or methods of obtaining and maintaining good will.

5. Personnel and its problems, including working hours and working conditions, wage schedules, and social security.

6. Supervision, or the coordination of all the individual units into an efficient organization.

A paper presented on September 20, 1939 at the Michigan Section Meeting at Lansing, Mich., by James L. Galloway, Marysville, Mich.

In this paper the author will discuss how the small water department, such as that at Marysville, Michigan, coordinates the above mentioned units.

In the majority of small plants, especially filter plants, the plant operator has the responsibility not only of operation but also of many of the duties which in a larger plant are handled by a superintendent. This is due to the fact that, in a small plant, the plant operator is generally the only employee holding a state license. Also, in a small department there are not sufficient funds, or work, to warrant the hiring of a superintendent. Consequently, the normal duties of a superintendent are divided among several of the city employees, with the plant operator receiving his share.

Responsibilities of Plant Operator

This condition exists in Marysville. Not only is the plant operator responsible for Unit 1, or the operation of the plant with the accompanying problems of treatment and mechanical difficulty, but his responsibility extends into several other units. The writer will pick out of the various units the work for which he is responsible, and follow this with the distribution of the remaining work among the other city employees.

Under Unit 2, or the distribution system, the only responsibility of the plant operator is in regard to meters. The meters are installed, read, taken out, or changed on his recommendation. At the present time this does not entail much work as the industrial meters are owned by the industries, and it is their responsibility to keep their respective meters in working order. The city has only 8 meters in service which it has to maintain. The work on these is done cooperatively with the Department of Public Works.

Under Unit 3, the office work with the accounting system, the billing, the correspondence, and the ordering, an unofficial accounting system is kept at the filter plant. Total water used by the industries is recorded as well as payment due for this volume of water. As the public is on a flat rate, the payment due for this usage remains approximately the same for each month. Total and operating costs are recorded and total profit shown. Also, all the correspondence and all ordering are carried on from the filter plant. However, on costly items, in spite of the delegated responsibility, it has been the practice first to discuss the desired purchase with the Mayor-Manager. This has tended to make for better understanding.

Unit 4, or public relations, is left entirely up to the plant operator. At the present time we are planning a series of sheets containing information and data about our plant and system. These will be included with the bills in an effort to make the public more water conscious, to make them appreciative of the responsibility of the water works employees, and of what the department is doing for them.

The responsibility of Unit 5, or personnel and their problems, rests mainly on the plant operator. He chooses the men whom he feels are qualified for the work they are to do, subject to the approval of the Mayor-Manager and the City Commission. He also makes the salary recommendations, although the Mayor-Manager and the Commission decide what the salaries shall be. In regard to social security, it is again up to the plant operator to prepare and present something in a workable plan for the consideration of the Mayor-Manager and the City Commission. At the present time we are working on a retirement pension system for the water works and city employees.

Responsibilities of Other Officers

Now let us go back to those units, or parts of units, that we have missed. The above was, as stated, the responsibility of the plant operator. The following fall under other heads.

Unit 2, or the distribution system, and all its branches, is handled by the Department of Public Works under the City Foreman. He is in charge of all installations and repair of mains, services, valves and hydrants, and meters. In other words, everything mechanical outside the plant comes under his jurisdiction. If extra help is needed for mechanical repair in the plant, as many of his men as are needed for the particular job are hired.

The balance of Unit 3, or the official accounting system and the water bills, are handled by the City Clerk. It is her records that are checked by the auditor at the annual audit of the City's books. She mails out water bills, collects payments, and keeps all the records pertaining to this unit.

The responsibility of Unit 6, or the coordination of the individual units into an efficient organization, rests in the Mayor-Manager. He is the acting head of all City departments, but he has delegated the responsibility of their operation to the various department heads. As long as a department is functioning properly and smoothly, he does not interfere with its operation, except for occasional sugges-

tions. Therefore much depends on the close cooperation between the heads of the Department of Public Works, the Fire Department, the Water Works, and the City Clerk, in making the organization efficient and a pleasant one in which to work.

We have covered all of the units as they have been outlined above. Let us now consider what responsibilities may in the future be placed on the plant operators.

The only trend at the present time in Marysville, is the change of responsibility for billing. The writer believes that, in the very near future, all the billing and collection of water bills will be handled from the filter plant. This will probably mean that the responsibility for the accounting system for the water works will also be moved to the plant.

However, in some small departments at the present time, the plant operator has the responsibility of all these various units. In fact he is the superintendent, the plant operator, the meter reader, the repair crew, the public relations man, and the clerk. This is a great deal of responsibility, may involve working long hours, and often times is not recompensed properly.

The small water department is an exceedingly general topic and may bring to mind many and varied lines of thought. It has been approached here from an angle hitherto seldom discussed, using the water department of Marysville merely as an example. It seems to the author that further discussion of this subject should be along the following lines:

1. What responsibilities do I have as head of my plant?
2. How many of these units can be successfully consolidated under the supervision of the plant operator?
3. What are the benefits and disadvantages of such consolidation?
4. What can be done to correct the disadvantages?

Differential Gas Pressures in Wells

By T. E. Larson

MANY who are in daily contact with wells may have had the opportunity to observe air being either sucked into the well or expelled from the well through whatever vent may be present. This action is pronounced and readily explainable as observed on starting and stopping pumping operations. In this event it is due to the respective lowering or raising of the water level in the well. Similar action at a much slower rate has been noted when the pump is idle or operating for a prolonged period of time at a constant rate.

Observations of the pressure of the air entering or leaving the well under such conditions confirm the theory that such action is due to the change in barometric pressure. As the barometric pressure increases the air (or gas), which is within the annular space above the water level between the concentric casings or between the casing and discharge pipe, is compressed forcing air from the atmosphere into the well. A drop in barometric pressure expands the enclosed air and forces the excess out into the atmosphere.

Recorded data during November, 1938 are shown with daily barometer recordings for the same period in fig. 1 for well No. 11 of the University of Illinois supply. This well is of gravel pack construction having a 36-inch outer casing and 26-inch inner casing both extending below the surface of the water and sealed air tight at the top except for a 2-inch pipe used for a vent. Since the water level is in the neighborhood of 100 ft. below the pump base-plate, the approximate air volume is 340 cu.ft. A drop in barometric pressure of 0.5 in. mercury will account for approximately 6 cu.ft. increase in volume of the enclosed air (or gas). The difference in pressure is slight but definite, and at one test the rate of transfer of air was 330 c.c. per minute.

A paper presented by T. E. Larson, Chemist, State Water Survey, Urbana, Illinois.

It is interesting and occasionally noteworthy to consider the effect of this fluctuation in pressure to force the well to "breathe."

First regard the well as merely an open hole in the ground without the effect of the presence of a pump. In nearly every case the water is just saturated with sufficient carbon dioxide to hold calcium in solution. With waters of any appreciable alkalinity, the partial pressure of carbon dioxide normally in the air is not sufficient to hold the carbon dioxide in the water. This is evident from simple

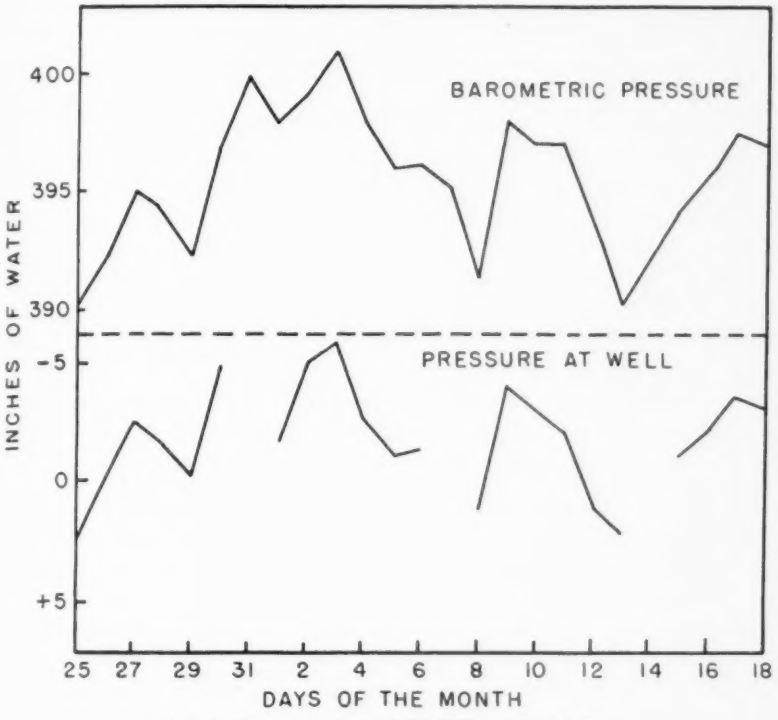


FIG. 1. Barometric and Well Pressure Data

calculations when it is considered that alkalinity (expressed as calcium carbonate) is always regarded as bicarbonate which in turn is actually a combination of carbonate, bicarbonate and carbon dioxide—the equilibrium ratio being dependent on the hydroxide (or hydrogen) ion content. The tendency is for the carbon dioxide to be expelled from the water to the air in contact and diffuse outward to the atmosphere.

Barometric pressure changes extract air with relatively high carbon dioxide content and replace it with air of normal atmospheric

carbon dioxide content. This process continues slowly but surely to decrease the carbon dioxide content of the water. This results in the tendency for precipitation of calcium carbonate from the water on sand grains or limestone or whatever solid material is in contact with the water. The greater the alkalinity and/or the calcium content, the greater will be this inclination.

This tendency is always present, but in most cases is nullified by other factors. One consists of anaerobic bacterial decomposition of organic matter, particularly in drift wells to give carbon dioxide and methane. In cases of too great an excess of carbon dioxide in the water, the loss cannot be made great enough to cause precipitation to take place.

On the other hand when a pump and screen are put in the well, operation of the pump causes reduction of pressure in localities of high velocity of flow, particularly at slots in the well screen. Fine sand has been found actually cemented together to form rocks as big as a fist. These "rocks" were found clinging to the slots on well screens where the pump capacity was too great for the size of the slots delivering this particular water into the well. Here the accelerated action is also aided by the decrease in pressure due to the lowering of the water level when pumping.

Another reaction that can take place is the oxidation of ferrous bicarbonate to precipitate ferric hydroxide due to the solution of oxygen from the air as replenished by the forced "breathing" process.

One other consideration is the presence of dissolved methane and nitrogen in the water. When present in concentrations greater than saturation they will be expelled from the water and "breathed" out into the pump house by fluctuating barometric pressure. Explosive hazards can thus be produced. If present in relatively high supersaturation concentrations, a continuous discharge is experienced, the rate of which varies with the barometric pressure. The well casing vent should extend outside the building to prevent a possible explosion hazard.

The extent to which this "breathing" can take place is exemplified by two wells on record. One in Illinois is described to give off a "roar when the wind is from the southwest" (low barometric pressure previous to a storm). Another in Mississippi is described as producing a "whistle that can be heard a half mile away just before a storm." Other cases are on record of former drift gas wells which now continuously draw air into the well at a rate varying with the barometric pressure.

Reaction of Heavy Doses of Chlorine in Various Waters

By A. E. Griffin

THAT chlorine will destroy tastes and odors in water has been known at least since 1919 when Sir Alexander Houston, in his report of that year to the Metropolitan Water Board of London, England, referred to such an effect. In a later report he presented data confirming his former statement, accompanied by the added information that as the chlorine dose increased the more certain would be the absence of tastes following de-chlorination. From that time to the present, with the possible exception of 1923, 1924 and 1933, at least one paper per year has appeared in the literature referring to the effect of heavier than normal doses of chlorine on tastes and odors.

In spite of this apparent wealth of material, consisting of at least 34 articles, surprisingly little research work has been reported dealing with chlorine doses greater than those barely necessary to effect sterilization. The feeling that much might be learned by a systematic search into the behavior of chlorine doses somewhat larger than those ordinarily used led to the launching of the present study by the Research Committee of the New Jersey Section of the A. W. W. A. The greater part of the material hereinafter reported was obtained from experiments conducted in the Research Laboratories of the Wallace & Tiernan Co.; from work done by members of the Wallace & Tiernan staff in the laboratories of various water purification plants; and from contributions submitted by workers in various parts of the country; together with data obtained in collaboration with the Chlorine Institute; or with the assistance of independent investigators, including Mr. Calvert of the Indianapolis Water Co.; Mr. Marsh and Mr. Lawrence of Cleveland; Mr. Billings

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of Dallas; Mr. Strockbine of Reading, Pa.; and Mr. Spaulding of the Hackensack Water Co. The general plan of investigation has been to re-study the indications reported by Howard, Scott, Gerstein, Hale, Calvert and others, that odors and tastes will disappear with increasing doses of chlorine and that frequently chlorine residuals may recede following an original rise with increasing doses of chlorine (an effect referred to on several occasions, but to which little practical significance had been attached).

Throughout the work residuals of less than 1 part per million have been determined by the ortho-tolidine method. Residuals greater than 1 p.p.m. have been determined by titration of at least 100 c.c. with sodium thiosulfate as per the instructions contained in the latest edition of *Standard Methods*.

Wherever possible all chlorine was added while the samples were being stirred at the rate of 75 r.p.m. Where stirring equipment was not available, the samples were stirred by hand, either by agitation of the containing vessel or by means of a stirring rod. Agitation was continued for at least 5 minutes. For the remainder of the contact periods the samples remained in a quiescent state. At the various pre-determined contact periods, samples were withdrawn for residual determinations and odor observations. In a few cases additional samples were drawn for color determinations.

The chlorine water in all experiments was obtained either by dissolving chlorine gas in the water regularly supplied to the chlorinator, or collected from the solution hose leading from the chlorinator to the point of application. In all cases these chlorine solutions were standardized daily. In special cases, where high temperatures prevailed, the chlorine water was standardized at the beginning of the forenoon and afternoon runs. With the exception of a few special cases the temperature of the samples under test remained practically the same for the period of each individual test.

Throughout the work it was standard practice to add the chlorine in equal increments, i.e. 1, 2, 3, 4 p.p.m. or 2, 4, 6, 8 p.p.m., etc. In certain cases increments as low as 0.1 p.p.m. were used. When the results were plotted, care was taken to keep the residuals and dosages on the same scale. By so doing the dosage curve always produced a 45-degree angle, thereby making it possible to compare the residuals with the dosage.

After several such curves had been prepared it became apparent that all were of the same general character, the main difference

lying in the amount of chlorine added. As the chlorine dose was raised, say from 1 through 5 p.p.m., the residual increased. Then as more chlorine was added the residual would decrease, sometimes disappearing altogether. By the addition of more chlorine beyond this point, however, the residuals would then rise usually very nearly in proportion to the dose. This phenomenon gave rise to such terms as the "hump and dip" or "breakpoint" in the residual curves. (See fig. 1.)

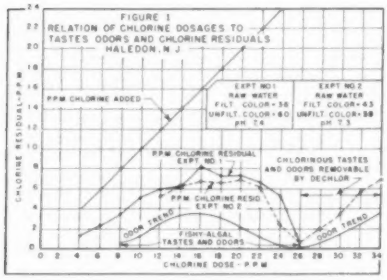
With these points established, attention was turned to the quality of the water at the various points along the curve. Here again a similarity was found, namely: that the tastes and odors in the raw water were frequently intensified in the high point of the curve, but either were greatly reduced or disappeared altogether at the dip or breakpoint. Quite frequently even the character of the tastes and odors changed as the chlorine dose increased. Where algae were present in the untreated water the tastes frequently became fishy, musty, or even unpleasant in the high region of the curve, slowly changing to sweet or chlorinous in character as the breakpoint was approached. From this point on the tastes were usually chlorinous and easily removed by some form of de-chlorination such as carbon, sulfur dioxide, or sodium bisulfite. In a few cases it was found that this sweetish, chlorinous taste would disappear upon standing.

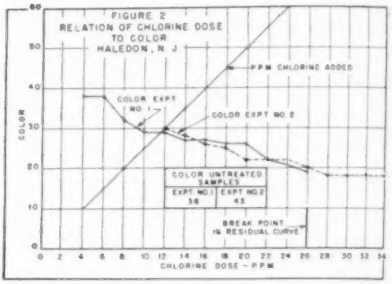
Such observations appear to be of particular value in the water works field where the production of a palatable water is one of the main functions of any purification plant. One of the most popular ways to accomplish this is by the addition of activated carbon. On the basis of this new information, however, it would appear that where minimum doses of chlorine are being used there are probably many cases where undue and unnecessary loads are being placed upon carbon. Certainly where such conditions prevail it would be better procedure to increase the chlorine dose up to or beyond the breakpoint, thereby giving the carbon a chance fully to perform the work for which it is intended. For example, at Cleveland, Marsh found that the addition of 0.4–0.5 p.p.m. chlorine increased the odor in the order of 10 threshold units. By increasing the chlorine dose to 0.7 or 0.8 p.p.m. this odor which had been raised to 60 by the lesser amount of chlorine was reduced to 12, practically all of which could then be easily removed by a minimum dose of carbon.

According to the best interpretation which we can give at the present moment, this increase in odor during the early stages of

chlorination is probably due to the production of a new set of chlorinated compounds, some of which have new and oftentimes penetrating odors. As the breakpoint is approached the concentration of chlorine becomes great enough to oxidize these chlorinated compounds, thereby eliminating their fishy, vegetable odor characteristics. According to our observations the change in the character of these tastes and odors is progressive, and the amount of chlorine necessary to bring about these changes varies with each individual water. As a matter of fact, it is quite possible and very probable that the oxidizing demand of each water will frequently change.

In several instances it was found that the super doses of chlorine materially reduced both the filtered and unfiltered color of the water. The greatest reduction found at any place was 50 per cent. At least one case is on record where the color was reduced from 60 to 30 follow-





ing a chlorine dose of 26 p.p.m. In another case the color was reduced from 20 to 10 under the influence of a 2 p.p.m. chlorine dose.

In fig. 1 we have an example of the meaning of receding residuals with increasing chlorine dosages. As indicated by the captions, these curves represent work done on two consecutive runs. On the first day the chlorine dose ranged from 4 to 26 p.p.m.; on the second from 12 to 34 p.p.m. It is to be noted that the trend in both is the same in spite of the fact that in the second experiment the residual did not quite go to zero.

In inspecting these curves one should not overlook the fact that the chlorine rise following the breakpoint is almost parallel to the chlorine dosage curve.

Here we have a very good example of how fishy, algal tastes and odors may prevail during the first part of the chlorine dose. It is to be noted that the intensity of the tastes and odors tends to rise

until the maximum residual of 8 p.p.m. is reached. At the minimum residual, or breakpoint, the tastes and odors decrease. From here on they are chlorinous in character, easily removable by suitable methods of de-chlorination. It is interesting to note that these observations check, in a general way, the 1928 figures of R. D. Scott, Chief Chemist of the Ohio State Department of Health on the action of chlorine on phenols (table 1).

The effect of these super doses on color is shown in fig. 2. In the first experiment the color dropped from 28 at the 6 p.p.m. dose, to a minimum of 19 at the 26 p.p.m. dose. In the second experiment the color dropped from 30 at a 12 p.p.m. dose to 18 at the 28 p.p.m. dose, with little, if any, drop beyond that point. These results are included as a matter of interest only.

TABLE 1

*Effect of Addition of Chlorine, and Chlorine followed by De-Chlorination upon the Taste of Scioto River Water Dosed with 0.1 p.p.m. Phenols**

ADDED	CHLORINE P.P.M. RESIDUAL AFTER 20 HOURS	RESULTING TA TE	
		Before De-chlorination	After De-chlorination
1	0.20	Chlorophenol	Chlorophenol
3	0.22	Chlorophenol	Chlorophenol
5	0.10	Chlorophenol	Chlorophenol
7	0.18	?	?
10	1.5	Chlorine	Absent
15	5.0	Chlorine	Absent
25	9.0	Chlorine	Absent

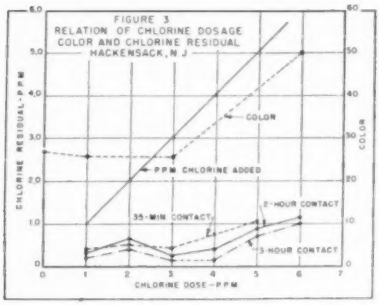
* SCOTT, R. D., 8th Ohio Water Conference, November, 1928.

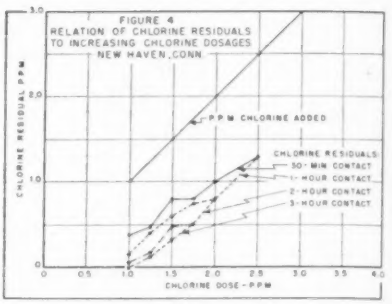
In fig. 3 we have an example of the same type curve as shown in fig. 1, except that the breakpoint occurs at a lower chlorine dosage. Here we find the breakpoint coming between the dosages of 3 and 4 p.p.m. Although the tastes and odors in this experiment, up to the breakpoint, responded similarly to experiences elsewhere, from this point on there was no production of chlorinous tastes and odors as had been expected, but rather an increase of disagreeable odors. Of course there is always the possibility that there may have been a secondary breakpoint where all disagreeable tastes and odors would have been removed. No attempt was made to find such a point, inasmuch as the color also increased. In view of these results it is doubtful that super-chlorination would be recommended for a water

of this type. However, of all of the waters studied, this is the only one which has reacted in this manner.

Figures 1 to 3 would lead one to believe that all waters will produce a sharp breakpoint in the residual curve. Figure 4, however, indicates that sometimes the breakpoint may resist detection. This curve, which was obtained by applying chlorine in doses from 1 to 2.5 p.p.m. to water obtained from one of the reservoirs at New Haven, indicates that the breakpoint lies somewhere between the 1.5 and 2 p.p.m. dose. This is substantiated by the fact that the odor changed from a bitter, disagreeable type at the 1.75 p.p.m. dose to one sweetish in character at 2 p.p.m. dose and beyond.

That the breakpoint does not always lie above the 1.0 p.p.m. dose is demonstrated in the work done by Marsh at Cleveland who finally found it to lie at an 0.8 p.p.m. dose (fig. 5) instead of at doses



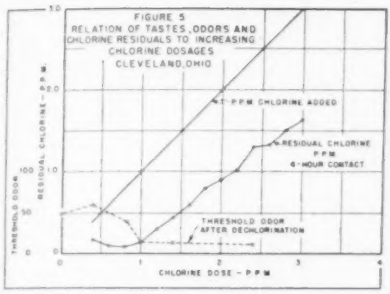


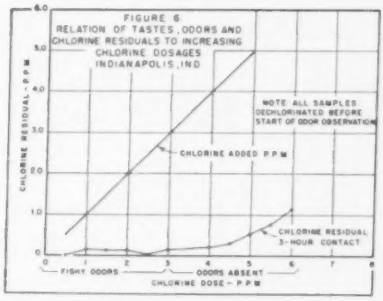
above 1.0 p.p.m. where the residuals persisted in remaining parallel to the dose. Here again there are indications that the tastes and odors frequently grow stronger during the early stages of chlorination, for Marsh found that the threshold odor of the water as drawn from the lake on August 29 increased from 50 in the raw to 60 after an application 0.4 p.p.m. chlorine. When 1 p.p.m. was added the threshold odor dropped to approximately 10, and was characterized as being sweet and chlorinous. From this point up to the 3 p.p.m. dose and where a residual of 2.04 p.p.m. prevailed after a 4-hour contact, the water after de-chlorination remained sweet and excellent to the taste.

Calvert, at Indianapolis, has duplicated these observations on several occasions. A typical chlorination curve of the water entering that plant is shown in fig. 6. Here the odors disappear as soon as the residual beyond the breakpoint begins to rise. The shape of

this curve in fig. 6 is worthy of some study. Here we find the residuals rising very slowly and only to a minor degree up to the 1 p.p.m. dose. Between the 1.0 p.p.m. and the 2 p.p.m. dose there is no further rise, with the breakpoint coming at 2.5 p.p.m.; then up again at 3 p.p.m., slowly rising through the 4 and 4.5 p.p.m. dose, gradually increasing and showing a tendency to parallel the dosage curve at 6 p.p.m.

The water from the East Branch of the Trinity River at the Dallas water intake on August 22, 1939, again exhibited the familiar breakpoint, this time at a dose of 12.0 p.p.m. In fig. 7 it is to be noted that the residual rises rapidly from the 6 to the 8 p.p.m. dose and then drops nearly as rapidly to the 12 p.p.m. dose, from which point on the residuals roughly parallel the dosage curve. Here again the tastes and odors first increase, then decrease near the breakpoint,





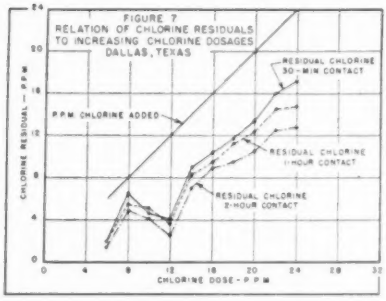
from which point on they are chlorinous in character and quite amenable to treatment with carbon or other de-chlorinating processes, such as sulfur dioxide or sodium bisulfite.

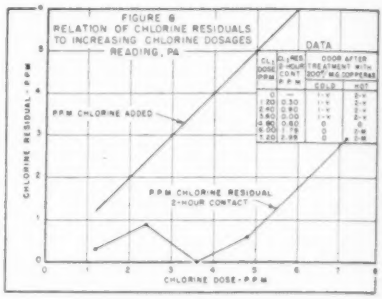
Reading, Pa. obtains its water from an impounding reservoir which is frequently subject to heavy growths of various types of algae. These are kept under control by frequent applications of copper sulfate. As so often happens, however, following the application of copper sulfate, the odors frequently increased to the point where ordinary filtration failed to eliminate them. To remedy this situation, Strockbine, Chemist in charge, decided early in the summer of 1939 to try the effect of super doses of chlorine. Preliminary laboratory runs indicated the breakpoint to be somewhere in the vicinity of 3.5 to 4 p.p.m. as shown in fig. 8. These amounts of chlorine were then added to the entire supply at a point in the supply conduit about 2 hours ahead of the plant. The results of this plant

scale test followed very closely the data obtained in the laboratory. From 0.5 to 1.5 p.p.m. residual remained when the water arrived at the plant where ferrous sulfate was applied for coagulation purposes. Copperas had the effect of completely de-chlorinating this residual, thereby putting it in the class of a de-chlorinating agent. This is the first recorded plant scale use of ferrous sulfate as a de-chlorinating agent, having been reported by Strockbine before the Four States Section Meeting on October 5, 1939. The experiments are being continued.

In addition to the above, similar results have been obtained on a laboratory scale at San Angelo, Texas; Little Rock, Ark.; Akron, Ohio; Butler, N. J.; Goshen, N. Y. and Stamford, Conn.

Further, the process is in regular operation at San Angelo and Tyler, Texas; Lawrence, Kan.; Upper Sandusky and Norwalk,





Ohio; Waterford, N. Y.; Weleetka, Okla.; and Richmond, Va. All report material improvement in the taste and odor of delivered water since the start of the treatment. Once the hump and breakpoint in the residual curve have been determined in the laboratory, it is a relatively simple matter to transfer these findings to plant practice.

Tyler, Texas, is an outstanding example where just this was done. Mr. Lloyd, Chemist in charge of the filter plant, was faced with a well nigh intolerable odor problem. Having exhausted every other possibility, attention was turned to the utilization of super doses of chlorine. Mr. Lloyd's work is particularly significant in that it appears that he had developed the chlorine residual "hump and breakpoint" idea on a practical scale nearly a year before it was fully demonstrated in the laboratory.

Likewise, at Waterford, N. Y., Yaxley has worked out a similar scheme calling for a chlorine dosage as high as 10 p.p.m. With

this dosage the taste and odor of the water has materially improved, heavier residuals are carried into the distribution system without danger of taste or odor, and gas-forming bacteria practically disappear. In fact, Yaxley reports that between July 22 and August 18, 1939, a period when an average of 9.45 p.p.m. chlorine was being applied to the raw water, not a single presumptive gas-former appeared in any of the samples collected from the basin inlet.

In conclusion, the data herein presented indicate that in practically all waters the residual curves produced by varying chlorine doses and standard times of contact will conform to the same general pattern; that this pattern is characterized by an initial rise in residual followed by a dip which is immediately followed by a secondary rise which will parallel the chlorine dose; that in many cases the odor of the water may frequently increase with the first rise in residual, but will usually disappear or become reduced to such a point at the dip or breakpoint that it can be readily and completely removed by suitable de-chlorination; and finally, that little bacterial life can persist wherever chlorination is carried into the zone of true oxidizing residuals, i.e., in the zone where the residuals rise following the dip, or breakpoint.

EDITORIAL NOTE: Neil Kershaw of Indianapolis, in a personal communication dated November 17, 1939, records the development of an alternate method of developing the chlorine demand curve. The raw water under consideration is heated to 110°F. before the varied doses of chlorine are added. After the chlorine is added, one-half-hour contact ensues and then the residual chlorine is determined on each individual portion. Parallel tests run to date indicate that this method correlates more closely with plant operating procedure than does the test run with the two-hour contact period. In a plant where chlorine demand determinations have a bearing upon operating conditions, any method which increases the rapidity of the determination is a valuable feature. On the other hand, Kershaw indicates that the chlorine demand procedure and the high chlorine dosages merit a greater study before dogmatic conclusions concerning the efficiency of the process are recorded.

Super-Chlorination for Taste and Odor Control

By J. M. Lloyd

THE writer's interpretation of super-chlorination means a treatment of raw water with chlorine solution to an end point where oxidation is complete. This type of treatment should be applicable to most lake supplies, and in some cases would probably be successful during the summer periods in treating river water containing a great deal of plant life. The writer does not believe that it could be used successfully, however, in the treatment of river water containing a great deal of mud, silt, etc.

Super-chlorination can be used in a filtration plant troubled with the taste and odor problem. Most of these odors are imparted to the water by algae, plant, and in some cases, animal life. These protein tissues from the above plants and animals contain, in varying percentages, nitrogen, sulfur, carbon, hydrogen, and oxygen. Organic compounds considered for treatment with super-chlorination deal with plant and vegetable bodies such as the alkaloids, quinine, etc., and may form stabilized salts when treated with acids.

The formation of hydrogen sulfide usually originates during the winter periods as a result of disintegrated plant life and algae growths settling on the lake bottom, which causes this strata of water to become void of oxygen. During the early spring months, changes in water temperature and especially nearest the shore line and in shallow water cause a lake turnover. This results in the bottom stratum of water becoming mixed with the top waters, causing in some cases a high carbon dioxide and hydrogen sulfide content which has to be treated. At this period, there is a distinct odor of hydrogen sulfide, and the pH also reaches its lowest point during the year. The color of the lake becomes quite turbid, as is indicated in some cases

A paper presented on October 17, 1939 at the Southwest Section Meeting at Dallas, Texas, by J. M. Lloyd, Superintendent, of Water Works, Tyler, Texas.

by a black and sometimes a yellow color. The black color in our lake is more indicative of manganese present than color from the plant life. From this point on throughout the summer periods, the plant and algae life become active, and it is from this point that super-chlorination is at its best advantage in the elimination of taste and odor.

In April, 1938, complaints on odors and taste were so frequent that chloramine treatment at the Tyler filtration plant was entirely eliminated. It was at this point that treatment was begun with copper sulfate on the whole lake. It was still found that even with a heavy dosage of the coagulant and longer filtration periods

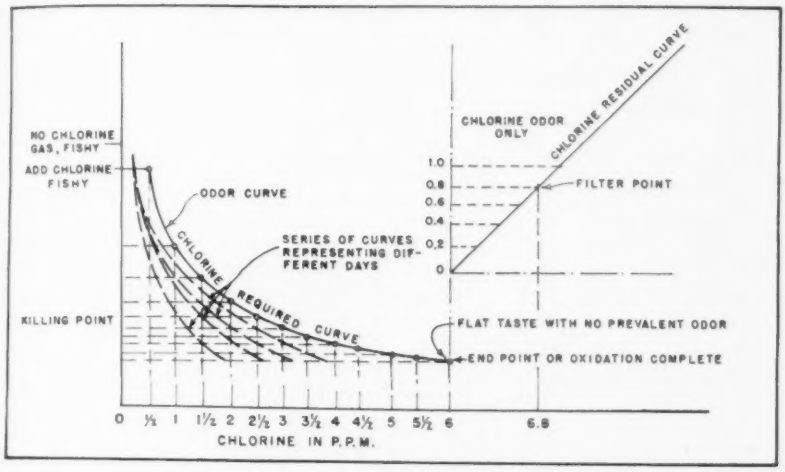


FIG. 1. Super-Chlorination at Tyler, Texas

it was impossible to alleviate the taste and odor problem. It was during this time that experiments were begun with super-chlorination as a means of eliminating these complaints. The results are indicated in fig. 1, and show a chlorine required curve which might be explained as follows:

1. Addition of chlorine to 1 p.p.m. gave a distinct fishy and plant life odor.

2. Addition of 2 p.p.m. gave a more pronounced musty odor, as well as the fishy and plant life odor.

3. Addition of 3 p.p.m. aggravated the taste and odor with a faint chlorine odor detectable.

4. Addition of 4 p.p.m. gave a slightly musty and sweet odor, also a slight chlorine odor.

5. Addition of 6 p.p.m. gave a flat taste, with no prevalent musty odor. At this point, there was no detectable odor.

6. Addition of 6.2 p.p.m. gave off a chlorine odor.

TABLE 1

Filtration Plant Data, Tyler, Texas

AVERAGE MONTH	CHLORINE TO RAW WATER	CHLORINE TO FILTER	CHLORINE TO DISTRIBUTION	pH OF RAW WATER	pH OF WATER AFTER CHLORINATION	pH OF TREATED WATER	CARBON DIOXIDE OF RAW WATER
	p.p.m.	*p.p.m.*	*p.p.m.*				
Began treatment Apr. 19, 1938	4.0	0.6	0.8	6.8	6.0	7.4	3.0
April 20, 1938	5.9	0.8	0.8	6.8		7.8	3.0
Avg. Remainder of April	6.5	1.0	0.8	6.8	5.8	8.2	3.0
May, 1938	6.0	1.0 to 0.8	0.8	6.8	5.6	8.2	3.0 to 5.0
June, 1938	5.5	1.0 to .8	0.8	6.8	5.6	8.0	4.0
July, 1938	5.5	1.0 to 0.8	0.8	6.8	5.6	8.0	6 to 11
August, 1938	5.9	1.0 to 0.8	0.8	6.8	5.6	8.0	8.0
	Cooler						
September, 1938	3.6	1.0 to 0.8	0.6	7.0	6.0	8.1	8.0
October, 1938	3.6	1.0 to 0.8	0.6	6.8	6.0	8.0	6.0
November, 1938	2.8	1.0 to 0.8	0.6	6.8	6.0	8.4	4.5
December, 1938	3.1	1.0 to 0.8	0.5	6.8	6.0	8.1	3.0
January, 1939	3.3	1.0 to 0.8	0.8	6.8	6.0	8.4	3.0
February, 1939	2.5	1.0 to 0.8	0.8	6.8	6.0	8.2	3.0
March, 1939	2.5	1.0 to 0.8	0.7	6.8	6.0	8.4	3.0
April, 1939	3.9	1.0 to 0.8	0.7	7.0	6.0	8.4	6.0
May, 1939	4.5	1.0 to 0.8	0.8	6.8	6.0	8.4	10.0
June, 1939	6.6 to 7.3	1.0 to 0.8	0.8	6.8	5.6	8.4	12.0 to 14.0
July, 1939	6.6	1.0 to 0.8	0.8	6.8	5.8	8.4	10.0
August, 1939	5.0	1.0 to 0.8	0.6	6.8	5.8	8.4	7.0

This experiment indicated that complete oxidation had taken place, and an end point had been reached. What organic compounds were formed the author does not know. It was found that it was not necessary to have any de-chlorinating agent, since the chlorine residual going to the filters was 0.8 to 1 p.p.m. During this period,

no chlorine odor could be detected escaping from the sedimentation basins. This is proven by sixteen months' operation in which no plant life, including shrubbery and roses growing adjacent to the basins, was killed.

The results also indicate that the proteins from the plant life, algae, etc., had to be stabilized and required definite amounts of chlorine in order that an end point could be reached where their odors imparted to the water would entirely disappear. It has been found that each day requires a different amount of chlorine. The data indicated that super-chlorination may be maintained during the winter periods by using as low as 2.5 p.p.m. chlorine. It was also

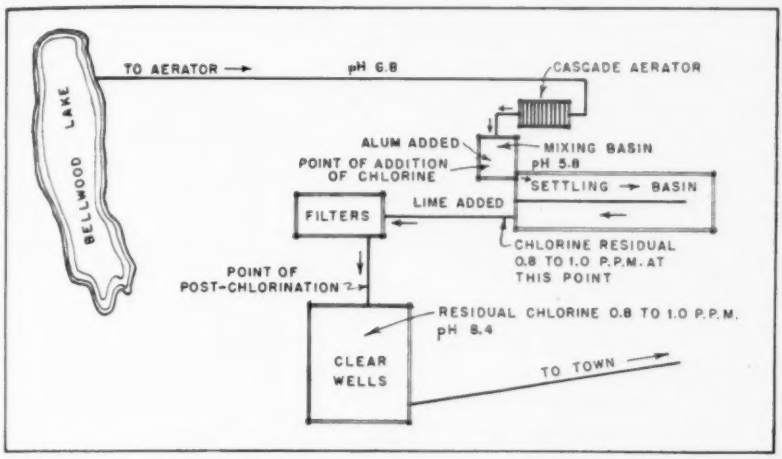


FIG. 2. Diagram of Water Plant Treatment at Tyler, Texas

found that more chlorine was required when the carbon dioxide and the hydrogen sulfide content in the lake increased. (See table 1.)

The advantages gained by super-chlorination in the Tyler plant are listed as follows:

1. Odors and tastes entirely eliminated.

2. Manganese partially oxidized by the chlorine, thereby giving longer filter runs during the spring periods.

3. Insured definite killing of bacteria, thereby relieving filters of some additional load.

Super-chlorination has proved beneficial at Tyler's filtration plant in the treatment of the raw water toward eliminating tastes and

odors. Where this type of treatment is planned, consideration should be given to the use of copper sulfate near the intake for preventing algae growths at that point. (See fig. 2.)

The writer is not in a position to say whether this treatment will prove satisfactory for raw lake water of an alkaline content but he believes this type of treatment worth a trial on such waters. It is suggested that in the treatment of some waters, de-chlorination by means of sulfur dioxide or granulated activated carbon may be necessary. The writer is of the opinion that super-chlorination will, in many cases, prove an effective treatment in eliminating all filtration plants' worst enemies—odors and tastes.

A Definition of "Available Chlorine"

By L. L. Hedgepeth and A. M. Buswell

SOME confusion concerning the term "available chlorine" has arisen within the last few years. This is due in part at least to the appearance on the market of products with much higher oxidizing power than the old "bleaching powder." If the "available chlorine" of these compounds is calculated in the manner used in evaluating bleaching powder a figure is obtained which not only exceeds all the chlorine in the compound but runs considerably over 100 per cent in some cases.

The term under discussion as defined forty years or more ago was "the weight of chlorine which could be obtained from a given weight of sample expressed in percentage." In France it was customary to express the strength of bleaching powder as "the number of liters of chlorine gas (S.T.P.) that could be obtained from a kilogram of the material." This definition assumed that the active ingredient, CaClClO, reacted completely according to the following equation:

$$CaClClO + H_2SO_4 \rightarrow CaSO_4 + H_2O + Cl_2 \quad (1)$$

If the material contained no inert ingredients the theoretical "available chlorine" of "bleach" was 55.85 per cent. The commercial material commonly ran from 25 to 35 per cent.

If the above definition is applied to some of the new products which contain a considerable amount of $Ca(ClO)_2$ as the active ingredient, we encounter the apparent anomaly that the "available chlorine" figures out to be practically 100 per cent. And we also find that we cannot write an equation similar to Equation 1 using H_2SO_4. If we use HCl we obtain:

$$Ca(ClO)_2 + 4HCl \rightarrow CaCl_2 + 2H_2O + 2Cl_2 \quad (2)$$

This material is submitted for the record by L. L. Hedgepeth, Manager, Technical Service Dept., Pennsylvania Salt Mfg. Co., Philadelphia, Pa.; and by A. M. Buswell, Chief, State Water Survey Division, Urbana, Ill., and Chairman of American Chemical Society Committee to Cooperate on Standard Methods. Any comments should be addressed to the EDITOR of this JOURNAL.

and the theoretical "available chlorine" is 99 per cent. Commercial products are on the market which show 70 to 74 per cent available chlorine.

Reports have reached us that calcium chlorite ($Ca(ClO_2)_2$) and sodium chlorite ($NaClO_2$) are soon to be on the market. These would react according to the following equation:

$$Ca(ClO_2)_2 + 8HCl \rightarrow CaCl_2 + 4H_2O + 4Cl_2 \quad (3)$$

$$NaClO_2 + 4HCl \rightarrow NaCl + 2H_2O + 2Cl_2 \quad (4)$$

and the theoretical "available chlorine" would be 162.09 per cent for Equation 3 and 156.79 per cent for Equation 4.

If objection is raised to a rating which gives values over 100 per cent some other term might be substituted such as "chlorine rating," "chlorine value" or "chlorine index." We do not believe this is necessary, however. We have gasoline of over 100 octane.

The question as to whether the various chlorites are exactly equivalent to free chlorine in the result produced in water is one which we do not wish to raise at this time and in this connection. There is apparently justification for difference of opinion. Since the inorganic reactions show complete equivalence between the chlorites and chlorine (within the limits of experimental error), we believe they should be rated in terms of chlorine.

In view of the above discussion we propose the following definition: *Available chlorine is the weight of chlorine given by reacting a given weight of sample under ideal conditions with an excess of HCl, the results to be expressed as per cent.*

The terms "residual chlorine" and "chlorine demand" are defined at present in terms of the ortho-tolidine test and might be stated as follows: "Residual chlorine is the amount of chlorine remaining for a predetermined time after treatment, as measured by the proper ortho-tolidine reagent" and "chlorine demand is the difference between the amount of chlorine added and the residual chlorine." Since the ortho-tolidine reagents all carry an excess of HCl they will react with the various chlorites mentioned above, producing chlorine in accordance with Equations 1, 2, 3 or 4, and hence will give a color proportional to the calculated available chlorine. It is apparent therefore that "available chlorine" is equivalent to "chlorine" in the two terms discussed in this paragraph.

Laboratory Control and Operating Experiences At The Hammond, Indiana, Filtration Plant

By J. C. Vaughn

BAYLIS once said, "It is the duty of every municipality to provide its citizens with an adequate supply of water that is clear, sparkling, pure and palatable at the lowest cost possible." The city of Hammond is seriously attempting to follow that precept. That the plant is subject to a very fine control is due to the fact that Leo Besozzi, formerly Supervising Engineer, who was also Engineer in Charge of Design and Construction, designed the plant so that comparative tests could be run on all materials used in the purification of water. He also included in the plant design very adequate laboratory facilities for the control of these tests and plant operations.

At Hammond the most used test is the Threshold Odor Test. This is very important because of the pollution of the source of the water supply, the southern end of Lake Michigan. This pollution was described in the paper "Experiences with Activated Carbon at Hammond, Indiana" (Jour. A. W. W. A., 29:1603 (1937)). Taste and odor pollution appears to have reached a peak about June, 1938. It is since reasonably low.

The threshold odor test is used at Hammond to determine the amount of carbon to be fed into the raw water. In the tabulation of results of the tests reported in the paper cited above, there was included the p.p.m. of carbon per unit threshold odor removed for carbons of different phenol values over a wide range of raw water

A paper which is a composite of papers presented: on April 8, 1938 at the Indiana Section Meeting at LaFayette, Ind., by J. C. Vaughn, Supt. of Filtration and Chief Chemist, Dept. of Water Works, Hammond, Ind.; on November 23, 1938 at a meeting of the West Shore Water Producers Assn. at Hammond, Ind., by J. C. Vaughn; and on April 26, 1939 at the Indiana Section Meeting at Indianapolis as part of a discussion by J. C. Vaughn of a paper by H. E. Hudson, Jr.



FIG. 1. Experimental Laboratory, showing stirring apparatus, ammonia stills (for carbon phenol test) and coal calorimeter.



FIG. 2. Preparation and Control Laboratory, showing separate refrigerators for media and water samples, autoclave still and threshold odor apparatus (right foreground, odor-free water setup).

threshold odor values. In the case of the reference carbon, there were at hand data covering the carbon requirements over the four-month period of the tests and covering a raw water threshold odor range of 3 to 100.

From this record it was easy to prepare a chart with a separate line for each carbon of a different phenol value, showing the parts per million of each carbon required to bring a given raw water threshold odor down to the finished water standard of three. (See fig. 3.)

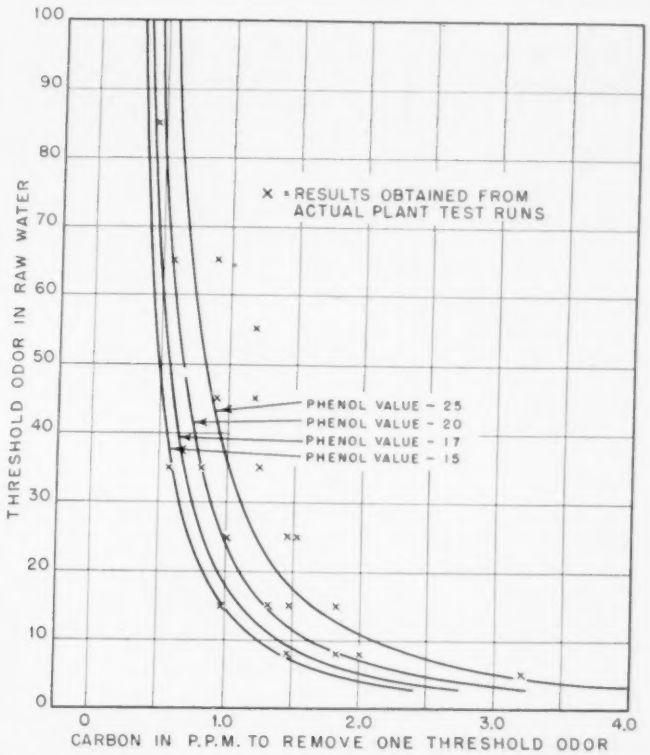


FIG. 3. Carbon Feed in p.p.m. Dept. Water Works, Hammond, Ind.

For a carbon of a given phenol value it was easy to transpose the p.p.m. required for a given raw water threshold odor into lb. per hr. for a given pumpage rate at that threshold odor. Mr. Besozzi prepared charts from this so that all the operator had to do was determine the threshold odor of the raw water, look on the chart and read off the pounds per hour of carbon for whichever pump was

running at the time. The carbon is fed at this rate until the next test, when the rate is changed according to the change in the threshold odor of the raw water. (See fig. 4.)

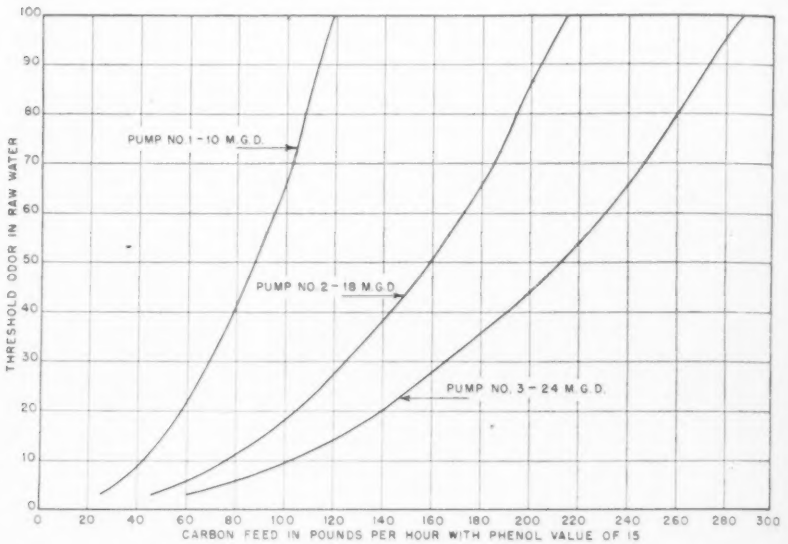


FIG. 4. Carbon Feed in pounds. Dept. Water Works, Hammond, Ind.

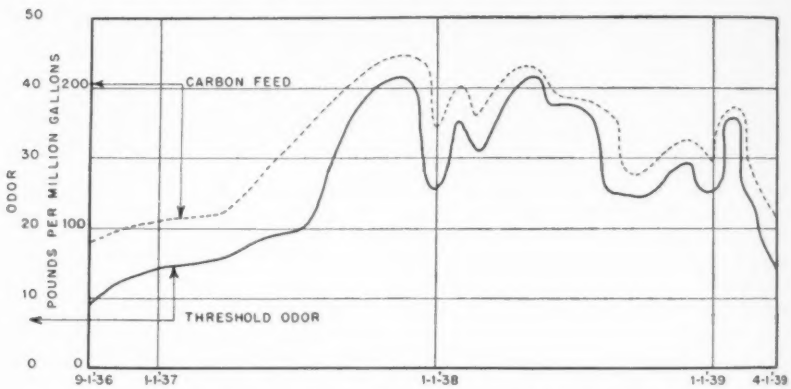


FIG. 5. Relative Trend of Raw Water, Threshold Odor and Carbon Feed in lb./m.g., Sept. 1, 1936–April 1, 1939.

It is interesting to note that two years' operation, feeding carbon on the basis of its phenol value as compared to the average phenol value of the reference carbon in the tests, has given a consistently satisfactory finished water from the standpoint of taste and odor.

By referring to fig. 5, it can easily be seen that the use of the more highly activated carbons which began about August, 1937 resulted in a much lower carbon requirement per unit of odor removed. In 1937 the cost per unit was just half the cost per unit in 1936 and in 1938 the cost per unit was reduced another 10 per cent from the 1937 figure.

Threshold odor tests are run on the raw water every two hours except when the change is very rapid. Then tests are run oftener. The same test is run on the tap water at four-hour intervals.

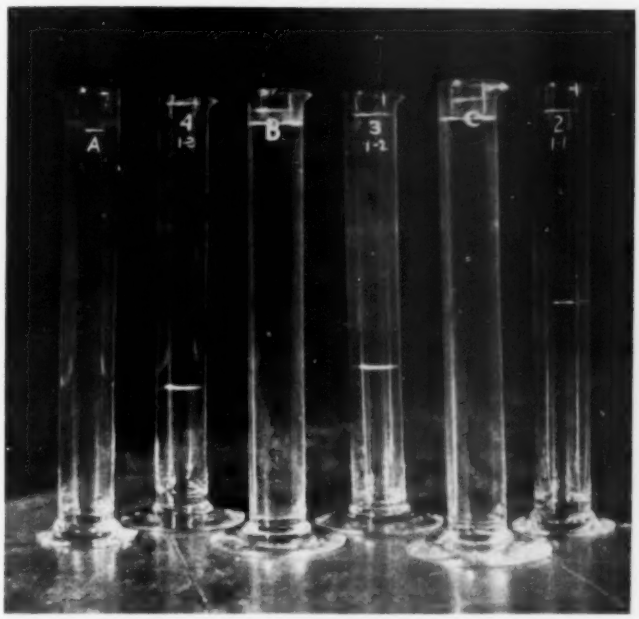


FIG. 6. Hydrometer Jars for Dilutions

The Baylis modification of the threshold odor test is used—as well as the Baylis nose-piece. It is necessary to modify the technique and lay down definite and very specific rules of procedure so that the operators may use the test with the greatest efficiency.

For making the dilutions, a series of 250 c.c. ungraduated cylinders (hydrometer jars) is convenient. (See fig. 6.) These may be marked directly at the proper levels for low dilutions; e.g., the mark at 125 c.c. would be labeled T.O. 2 as it would be used for diluting one volume, 125 c.c. of odor-bearing water with odor-free water to give a total volume of 250 c.c.

The mark labeled T.O. 3 would be at 83 c.c., $\frac{1}{3}$ of 250 c.c., for one volume of odor-bearing water and two volumes (167 c.c.) of odor-free water. Cylinders for T.O. 3, 4, 5, 6, 7, 8, 9 and 10 can be similarly marked. For T.O. 10, for example, the mark would be at 25 c.c., $\frac{1}{10}$ of 250 c.c., and would provide for one volume, 25 c.c., of odor-bearing water mixed with nine volumes, 225 c.c. of odor-free water, or ten volumes all together. In table 1 are shown dilution figures from 1 to 100:

For threshold odor values greater than 12, the volume of sample to be used cannot be measured with sufficient accuracy by marks on a 250 c.c. cylinder. For values between 12 and 25 inclusive, a

TABLE 1

Volume of Odor Bearing Water to Use for T.O. Dilutions from 1–100 in a 250 c.c. Cylinder

DILUTION NOS.	C.C. SAMPLES IN 250 CC.	DILUTION NOS.	C.C. SAMPLES IN 250 CC.
1	250	18	13.9
2	125	20	12.5
3	83.3	25	10.0
4	62.5	30	8.3
5	50.0	35	7.1
6	41.7	40	6.3
7	35.7	45	5.5
8	31.3	50	5.0
9	27.7	60	4.2
10	25.0	70	3.6
12	20.8	80	3.1
14	17.9	90	2.8
16	15.6	100	2.5

25 c.c. graduated cylinder may be used, although a 25 c.c. graduated pipette is better. For values above 25, it is necessary to use a graduated pipette. For these dilutors the cylinders marked at the 250 c.c. level and labeled A, B, C, and D may be used.

When considering coagulation at Hammond, it must be remembered that so much carbon is added to the raw water that all normal standards of evaluation of the effect of turbidity are useless. The turbidities of the raw water are taken merely as a matter of record. Coagulants are evaluated on the basis of comparative filter runs for the same season of the year; per cent turbidity settled out (taken from the difference in turbidity of the influent and effluent of the

settling basins); and the effect on the volume per cent of mud balls in the top 6 inches of the filter. It is recognized that both the length of the filter runs and the mud ball count are largely seasonal. That is why coagulants are compared on the basis of their efficiency at the same season of the year. Early in the beginning of operations it was found that 0.8 g.p.g. of alum was the maximum dosage necessary for Lake Michigan water.

Similarly in 1938 it was found that 0.6 g.p.g. of chlorinated copperas was the optimum amount, and in 1939 it has been found that 0.3 g.p.g. ferric sulfate is the most required to produce comparable

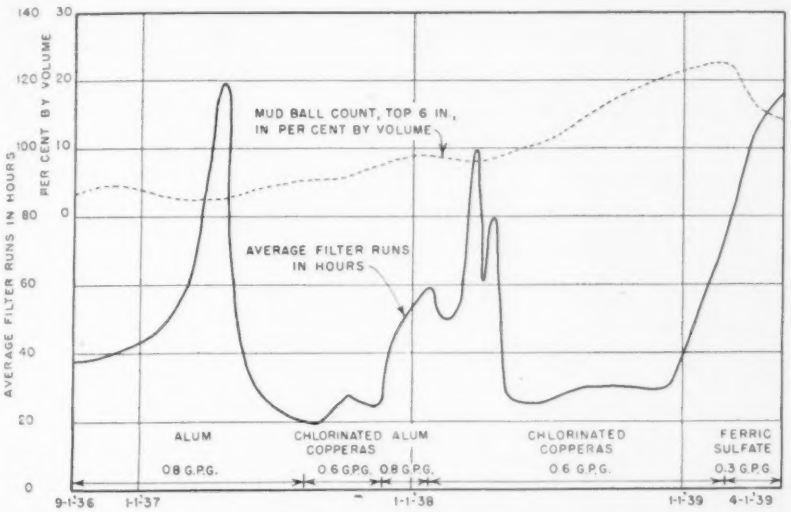


FIG. 7. Average Filter Runs (in hours), Mud Ball Count (per cent by volume—top 6 in.), and Dosage of Coagulants, Sept. 1, 1936–April 1, 1939.

results. In addition, the ferric sulfate has sharply reduced the mud ball count. Ferric sulfate is now used, at a total chemical cost for coagulation of less than $0.80 per million gallons. The percentage turbidity settled out ranges from 80 to 95 per cent for the three coagulants. The comparative effects of the three coagulants on filter runs mud ball count may be observed in fig. 7.

In the comparison of different kinds of coagulants a more precise idea of the relative "floc" size under similar conditions seemed important, so a device for measuring floc size was developed. The device consists of a glass-bottomed tray, $4\frac{1}{4}$ in. wide, 6 in. long and 2 in. deep, mounted on a submarine lamp. The glass bottom is

lined off in areas (5 cm. square) by 1 mm. lines in 2, 3, 4, 6 and 8 mm. squares, respectively. The cord is plugged in and the device is dipped into the tank or basin containing precipitant or floc. The device is brought to the surface, so that the side walls of the tray will prevent the cross currents in the tank from disturbing the "floc."

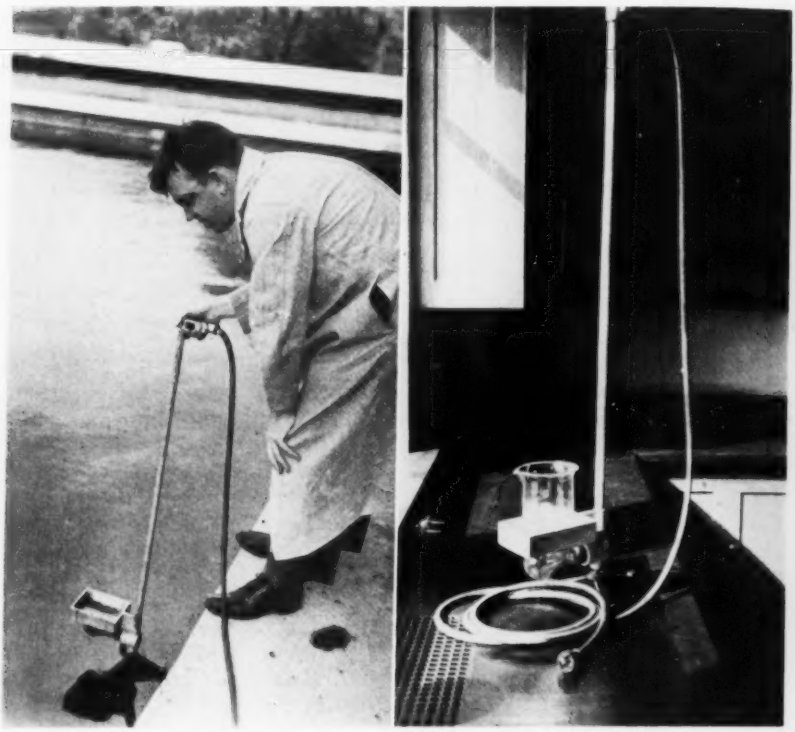


FIG. 8. Plant and Laboratory Uses of Floc Evaluator; this one built by a laboratory supply house.

The light is switched on and the size of the floc is evaluated by comparing the particle size with the various sized squares. The submarine lamp is mounted on a tripod so that it may be placed on the desk for laboratory use. The tray is large enough to hold a one-litre beaker so that the floc can be evaluated without being transferred (which breaks it up). (See figs. 8 and 9.) This device has enabled us to regulate out stirring rates so as to obtain uniform floc size and settling in the two halves of the plant.

The Baylis method of determining the mud ball content of the top six inches of the filter layer is used. This involves the use of a 3 by 6 inch (inside dimensions) brass cylinder, with which a number of samples uniformly distributed over the filter area, are taken. The mud balls are sieved out under water through a 10-mesh screen, the volume of the mud balls being determined by water displacement and the percentage calculated from the total volume of sand taken. The Hammond filtration plant, unfortunately, has no surface wash system so we have made a device of our own to accomplish the same end. To break up the mud balls we have made a rake—the handle

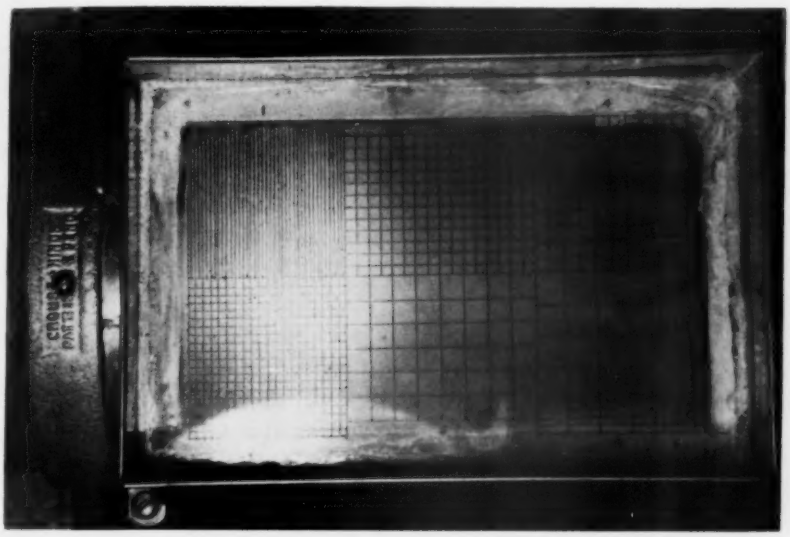


FIG. 9. Counting Grating of the Floc Evaluator

of 1 inch pipe, the back of this rake proper of 1 inch tees and nipples and the tines of 8 inch sections of $\frac{3}{8}$ inch pipe plugged at the lower ends. The sides of the tines are drilled with $\frac{3}{32}$ inch holes 1 inch apart. The end of the handle takes a 1 inch hose. The rake is used while the filter is being washed. The cross jets from the tines very successfully break up the mud balls. The rake is shown in fig. 10.

We would like to eliminate all pre-chlorination but because of the abnormally high coliform bacteria count of the raw water, it cannot be done. On the few occasions when elimination of pre-chlorination has been tried, bacterial growths have always begun to

form on the filters. With four days at a peak of 160,000/100 c.c. (M.P.N. count) and a yearly average of approximately 3,500/100 c.c. one cannot afford to risk not pre-chlorinating. The chloramine demand across the plant ranges from 0.06 p.p.m. (on the basis of the chlorine) to 0.58 p.p.m. or about 0.22 p.p.m. average. When the bacteria count goes up so does the demand but not proportionately as might be expected.

Previously we have reported that carbons were most efficient at a pre-chlorination feed of 0.3 p.p.m. with ammonia in the ratio of 2 parts chlorine to 1 part ammonia. Since the average plant demand is 0.22 p.p.m. we follow the practice of 0.3 p.p.m. pre-chlorination, except during the summer months when this is increased to 0.4 p.p.m. and 0.5 p.p.m. because of excessive bacterial pollution.

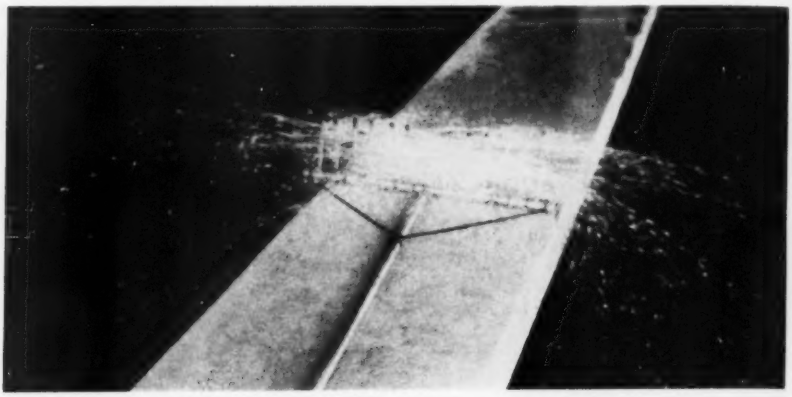


FIG. 10. Rake for Breaking up Mud Balls

The 2:1 ratio of chlorine to ammonia is used throughout the year except during March when fixation of tastes occur which the reduction of ammonia ratio seems to help.

However, if this ratio is lowered during the rest of the year chlorinous tastes result. The ammonia cannot be eliminated altogether because phenols are always present and the very obnoxious chloro-phenols would result.

The filtered water is chlorinated as it goes into the reservoir. The amount varies so as to keep the plant tap water at about 0.45 p.p.m. The reservoir water does not show any tendency further to absorb chloramines except when the temperature of the water is above 65°F. Whether this is a temperature, time or pollution function, has not yet been determined.

The danger of elimination of pre-chlorination was emphasized by a recent experience. Upon one day the influent water chlorine demand increased faster than the operators could increase the dosage. The raw water showed a bacterial count of 24,000/ml. The filtered water showed a count of 23/ml. but for one day only. Had we depended on post-sterilization alone to destroy whatever bacteria passed the filters we would have distributed a contaminated water. Pre-sterilization will always reduce the bacterial load to such a point that post-sterilization will destroy whatever bacteria pass the filters and still maintain a satisfactory residual. The use of ammonia with the chlorine reduces the chlorine demands. Twelve pounds of chlorine and 6 lb. of ammonia per million gallons are the maximum now, while sometimes as much as 50 lb. of chlorine per m.g. were used when chlorine alone was employed. We believe chloramination to be not only more effective, but also more economical than straight chlorination.

The sudden influx of highly polluted water mentioned above was just a part of the troubles of such nature that have been experienced since December 1, 1938. About this time the hardness of the raw water began to increase. This had been very constant at 128 p.p.m. for years. It increased to 171 p.p.m. The bacteria count during the winter season is usually under 300/ml. This year it increased to a monthly average of over 8,000/ml. The chloramine demand across the plant for this season of the year is usually 0.2 p.p.m. or less. This year it has risen and remained above the summer-time average. These evidences of an increase in the pollution of the water supply began to appear about December 1, 1938. This coincides perfectly with the decreased diversion of Lake Michigan water by the Chicago Sanitary district. The result was an increased backflow of South Chicago Sewage through the Calumet River into Hammond's supply basin. The effect may be seen in fig. 11.

Other laboratory tests such as carbon dioxide, hardness, pH alkalinity, color and iron are run on the water but are not pertinent to the operation of the plant.

A careful and exact method has been worked out by which carbon may be fed so as to remove the taste and odors most efficiently. Two and one-half years' operation at Hammond prove that more highly activated carbons remove proportionately more tastes and odors.

The per cent settled out in the settling basins as measured by turbidities of the mixed and settled water, together with the length

of filter runs and effect on mud ball count, is used to evaluate the efficiency of coagulants.

Pre-chlorination and pre-ammoniation are utilized in such a way as to give a sterile water coming off the filters without any fixation of tastes.

Both the coagulation and the chloramine treatment are applied in such a way as to permit the most efficient use of the carbon.

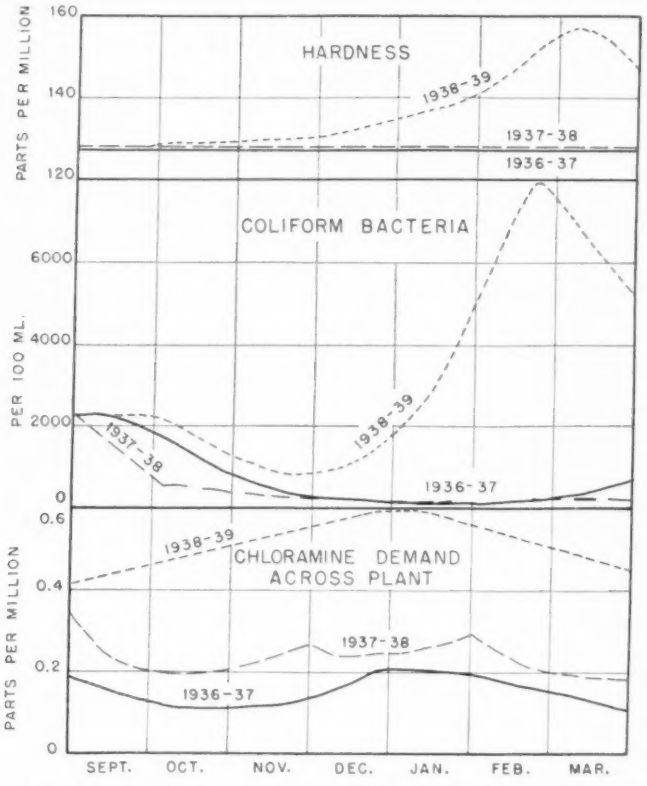


FIG. 11. Graphic Illustration of Change in Water Supply for Hammond, Ind.

Decreased lake diversion by Chicago, causing the Calumet River to flow back into Lake Michigan, has resulted in great increases in bacterial count, chloramine demand, and hardness of Hammond's raw water supply.

The author wishes to express his appreciation of the work done by Mr. Bussert of the Hammond staff in developing the original graphs for this paper and to John R. Baylis for his guidance and inspiration.

Studies in the Use of Sodium Silicates

By H. E. Lordley and Marsden C. Smith

THE use of silicates as an aid to coagulation in water purification was suggested by John R. Baylis (Jour. A. W. W. A., **29:** 1355 (1937)). To Baylis is due much credit for his work and the authors of this paper wish to emphasize that what follows is in no way a criticism of his results. It is instead merely a report of the studies and facts developed by them in an effort to determine the value of the use of silicates at the Richmond plant and is presented here with the single purpose of adding to the knowledge of the subject so ably presented by Baylis.

The source of water for the Richmond plant is the James River, a stream which offers a wide variation in quality, hence creates an ideal subject for such a study. This is indicated by the fact that the temperature of the supply varies from practically zero to 30°C., the turbidity from 5 to 3200 parts per million and the alkalinity from 18 to 75 p.p.m. In addition, industrial wastes from paper mills and tanneries add their complexities, allowing the evaluation of silicates, as an aid to coagulation, to be still more comprehensive.

During the period of more than a year that these tests have been conducted, the raw water quality did not vary through as wide a range as is frequently the case. However, as the tables indicate, the variations actually occurring are sufficiently broad to allow a true appraisement of the problem.

In the hope that much time may be saved other investigators we here record our experiences in the selection of the most suitable source, type and treatment of silicates. It will be noticed that much of this part of the report confirms, but we hope extends, Baylis' original report.

A paper presented on September 8, 1939 at the Virginia Section Meeting at Charlottesville, Va., By H. E. Lordley, Superintendent of Filtration, Richmond, Va.; and by Marsden C. Smith, Chief Engineer, Department of Public Utilities, Richmond, Va.

Untreated silicic acid was used but it was found that it is of no value when used with alum for the coagulation of water. Silicic acid treated with caustic soda in a quantity sufficient to produce an alkalinity of 1,200 was tried, but this also was found to be of no assistance.

Many supplies of lump and powdered sodium silicate were used and, strange to say, only one of these was found to be readily soluble in water and that with the solution water at not less than approximately 80°C. Three other supplies were found, all in the liquid state, which, when treated with sulfuric acid and used in comparative tests, developed efficiencies as shown in table 1.

Thus it may be seen that, while the powdered supply is slightly more efficient, this advantage is not great enough to justify its higher cost than the liquid forms. It may be well to note that in all tests included in the actual coagulation studies here reported, the analyses of the silicates used after an acidification to alkalinity 1,200, proved to be quite similar and to contain approximately 8.85 per cent sodium oxide and 28.7 per cent silica dioxide.

As Baylis has stated, the alkalinity adjustment is of the greatest importance and apparently 1,200 is the optimum value. Any material change from this value, either more or less, will result in difficulties.

The solution should be aged for several hours before using but if more than a week old should be discarded, since a rapid reduction in activity occurs after that time.

Test Methods

The authors are convinced that neither the time required for a physical floc to form nor its physical appearance can be safely used as a measure of the coagulation efficiency. In fact, they are certain that it is possible for a floc to form too rapidly for best results, and that oftentimes the adsorptive capacity of a larger floc is decidedly less than one not so massive. Hence, while these observations may frequently form a correct measure of the relative coagulation results, they are often quite misleading.

What we believe to be an original method of evaluating coagulation results is based upon the time required to filter a given sample of coagulated water. When this is done under standard conditions, such as those empirically determined by the authors, the results

have been found to be very much more accurate than we have been able to obtain by any other method.

Briefly, the technique to determine the "time of filtration" requires the use of standard #12 Whatman folded filter paper in long stem, three-inch funnels of uniform bore. The positive and negative heads on the filter are accurately standardized. After an exactly similar stirring and settling time, water is taken from the top of the beaker by means of a large pipette, with care not to disturb the settled floc, in a quantity sufficient to fill a 200 c.c. volumetric flask. The flask is then closed with a stopper that may be easily removed, inverted and placed in the funnel, the stopper opened, and the time required to filter the 200 c.c. is recorded as the "time to filter."

Many may deem this procedure unduly exact, but plant operating experience over an extended time has proven it to be an extremely

TABLE 1

Relative Efficiency of Suitable Sodium Silicates

SUPPLY	PHYSICAL STATE	SiO_2 USED*	ALUM USED*	FILTER TIME**
1	Powder	12.5	200	2.48
2	Liquid	12.5	200	2.55
3	Liquid	12.5	200	2.58
4	Liquid	12.5	200	2.62

* Pounds per million gallons.

** Time in minutes to filter 200 c.c. under standard (empirical) conditions (see text).

reliable and sensitive method to determine the efficiency of coagulation. After all let us remember that coagulation is used in water works plants only to aid filtration. Hence the only sensible measure of the success of coagulation is the filterability of the settled water.

However, in an effort to increase the accuracy of coagulation evaluation, the time, physical appearance of the floc and supernatant water have been recorded in all tests.

Because of the time required for accurate results in tests of this nature and the evident limited aid that could be obtained from the use of silicates in Richmond, the results here presented are founded not upon a large number of tests but upon a sufficient number covering a wide variation in raw water quality. With the care taken that each test should be as accurate as is possible, we are confident that more frequent tests could have changed the results but slightly.

It is important to record that all temperature readings given in this report are the actual intake water temperatures. No tests in which the temperature was artificially controlled are reported. Also silica has not been used at Richmond on a plant scale and, hence, this report is based entirely upon laboratory studies.

Results with Alum

The difficulties always encountered when attempting to express the results of a study of this nature are generally known. Some operators have a supply that contains so little material to be removed that coagulation and filtration are but little more than important luxuries. In such plants almost any type of floc that will settle is successful.

Other plants require a floc of great adsorptive power if successful operation is to obtain. Certain it is that for these plants many apparently well treated waters are found to be not so efficient when reaching the filters as are others which are apparently less successfully coagulated.

It has long been recognized that an increase in turbidity requires an increase in the quantity of the coagulant for best results; but that at nearly zero turbidity an increase in this condition of the raw water improves coagulation. Consequently, it is not surprising that at Richmond silicates aid coagulation at very low turbidity; but that after a slight increase in turbidity, the benefit rapidly becomes neglibile.

Table 2 has been prepared using tests on water of approximately the same temperature to show the effect of varying turbidities. It is striking to note that at the lowest turbidity recorded, there is an improvement in all floc indices except filtering time; but after the turbidity exceeds 25 p.p.m. only the "time to appear" indicates that the addition of silicates has aided coagulation. The apparently large ratio of silica to alum used in these tests was adopted because it has been conclusively proven that small ratios (please refer to samples 21 to 24, table 2 which have been recorded as examples) have little or no effect. To indicate further this point it is noted that in table 2 we have selected tests in which the amount of silica bears a smaller ratio to the amount of alum used.

Consequently, it appears that at very low turbidities there is a definite aid by sodium silicates in forming a larger floc and in less

time. At higher turbidities, however, this aid to coagulation may actually become detrimental.

Table 3 has been prepared using tests on water having approximately the same turbidity, intentionally less than the Richmond average, to permit the effect of temperature change to be better

TABLE 2

Temperature Effect on Coagulation—Sodium Silicate with Alum

	RAW WATER					COAGULANT		FLOC			
	Temp. Cent.	Turbidity	Color	Alkalinity	pH	SiO_2	Alum	Time to Appear	Relative Size	Liquid Appearance	Relative Filter Time
		p.p.m.	*p.p.m.*	*p.p.m.*		*p.m.g.*	*p.m.g.*	*mins.*			
1	8.5°	6	31	45	7.3	0	250	3	8+	1.2	3.25
2			Same			50	250	1	9+	.9	3.43
3			"			75	250	1−	10	.75	4.90
4			"			100	250	.75	10	.60	5.10
5	11°	28	42	34	7.1	0	150	2	9	1.0	2.83
6			Same			50	150	2	7+	1.2	6.42
7			"			75	150	1.25	7	1.1	10.00
8			"			100	150	1.5	6	1.4	15.00
9	12°	50	35	32	7.0	0	150	2	8+	1.2	3.08
10			Same			50	150	1.5	9+	1.2	3.75
11			"			75	150	1.5	8	1.2	5.67
12			"			100	150	1.5	7	1.8	Excessive
13	11°	75	50	31	7.1	0	175	1.5	8+	1.0	2.86
14			Same			50	175	1	7	1.4	4.22
15			"			75	175	1−	7	2.1	4.58
16			"			100	175	.75	5	4.5	8.33
17	10°	150	60	28	7.1	0	225	2.25	8+	1.3	3.08
18			Same			50	225	1	8	1.3	3.05
19			"			75	225	1−	8	2.2	5.00
20			"			100	225	1−	8	5.4	8.91
21	5.5°	60	48	34	7.1	0	200	2	8	1.0	3.33
22			Same			12.5	200	1.74	8	.9	3.33
23			"			25.0	200	1.75	9	1.0	3.43
24			"			37.5	200	1.5	9+	.7	4.42

illustrated. Again it is striking to note that at very low temperatures all floc indices except "filter time" indicate a marked aid by the silicates. However, as in the case of turbidities, after the temperature increases this aid becomes less and less until at the maximum temperature all measures indicate that the silicates actually reduce the efficiency of coagulation.

So it appears that at very low temperature silicates are an aid to coagulation if turbidities are below 50 p.p.m.; at about 10°C. there is but little benefit and at about 20° and above the silicates are actually detrimental.

TABLE 3

Turbidity Effect on Coagulation—Sodium Silicate with Alum

RAW WATER					COAGULANT		FLOC			
Temp. Cent.	Turbidity	Color	Alkalinity	pH	SiO_2	Alum	Time to Appear	Relative Size	Liquid Appearance	Relative Filter Time
	p.p.m.	*p.p.m.*	*p.p.m.*		*p.m.g.*	*p.m.g.*	*mins.*			
5°	10	35	46	7.3	0	175	3	8+	1	5.00
		Same			50	175	1.5	9+	0.7	5.25
		"			75	175	1.25	10	0.6	5.00
		"			100	175	1	8+	1	8.00
9.5°	10	30	33	7.1	0	150	3	9	.9	3.42
		Same			25	150	2.5	9	.8	3.08
		"			50	150	2	8	1.0	4.75
		"			75	150	1	7	1.4	6.33
15°	12	30	43	7.3	0	175	1	9	0.7	3.50
		Same			25	175	1	9	0.7	3.50
		"			50	175	1	10	0.8	5.00
		"			75	175	1.5	7	1.6	7.00
20°	5	35	44	7.3	0	150	1	9+	0.6	4.33
		Same			25	150	1+	9	1.0	6.10
		"			50	150	1.25	8	2.1	Excessive
		"			75	150	3	7	2.8	Excessive
28°	8	25	35	7.2	0	150	1	9	0.7	3.83
		Same			25	150	1	9	0.7+	4.33
		"			50	150	1.5	8	0.9	6.25
		"			75	150	1.5	6	1.8	8.00

Results with Iron

A series of tests was made using Richmond water to determine the effects of silicates when iron in the form of ferric chloride, ferric sulfate and chlorinated ferrous sulfate were used as the coagulant. Table 4 has been prepared to show the results of these tests. It will

be seen that in all cases the silicate definitely inhibits coagulation when any one of the commonly used iron salts is the coagulant.

As has been previously reported, the Richmond plant has found that the use of chlorinated copperas completely eliminates the difficulty encountered in obtaining satisfactory coagulation with alum the coagulant, if the temperature of the water be less than 5°C. Also it has been reported that for many years we have used the

TABLE 4

Sodium Silicate with Iron Salts

RAW WATER					COAGULANT		FLOC			
Temp. Cent.	Turbidity	Color	Alkalinity	pH	SiO_2	Iron Salt	Time to Appear	Relative Size	Liquid Appearance	Relative Filter Time
Ferric Sulfate										
	p.p.m.	*p.p.m.*	*p.p.m.*		*p.m.g.*	*p.m.g.*	*mins.*			
10°	24	34	32	7.0	0	275	1−	8+	1.8	5.42
		Same			50	275	1.75	8	2.4	11.25
		"			75	275	2	7	4.5	Excessive
		"			100	275	4	7	5.0	Excessive
Ferric Chloride										
20°	5	35	44	7.3	0	125	.75	9	0.7	3.83
		Same			25	125	.75	8	1.2	6.00
		"			50	125	1	7	2.1	Excessive
		"			175	125	4	4	2.8	Excessive
Chlorinated Copperas										
		Same			0	225	.75	9+	0.6	4.50
					25	225	1	7	1.3	9.17
					50	225	2	5	2.2	Excessive
					75	225	5	4	2.8	Excessive

combined treatment for waters having a "descending" turbidity. That is, when alum or chlorinated copperas is used alone in waters, the turbidity of which is decreasing, poor coagulation is obtained and a colloidal, non-settling turbidity greatly increases the burden on the filters. If a small quantity of the other coagulant be added to that being used at the time, there results a marked reduction or a complete elimination of this troublesome and frequently serious

condition. Since this practice has been reported and demonstrated for so many years, we mention it here only as a possible clue to the cause of the detrimental effect of silicates on coagulation when used with the iron salts.

Summary

1. Sodium silicates properly prepared and used in the correct ratio almost always produce a floc more rapidly than will alum alone.

2. The floc is generally larger and of improved physical appearance and settles more rapidly.

3. Except at low temperatures and turbidities, the floc produced when the silicates are added appears to be much less adsorptive and the settled water less suitable for filtration.

4. With iron salts it appears definitely detrimental to coagulation.

5. The cost and inherent difficulties of storing, handling, acidifying and using the sodium silicates would greatly increase the practical problems of plant operation.

6. Where difficulty is experienced with low temperatures and turbidities, iron salts appear to be a much preferred alternative to alum with silicates.

7. Where adequate settling time is not available and mechanical aids to coagulation with iron salts fail to reduce the settling time required, the use of silicates with alum appears to be the best solution of this condition yet known. The authors are, however, satisfied that filter runs are apt to be materially reduced.

Building Up Valve Seats by Bronze Welding

By G. G. Routledge and W. A. Duncan

CAST-IRON and cast-steel valves for service such as in water mains have usually been constructed with cast-bronze seats either rolled into machined dovetailed grooves in the body and the gate, or else secured by screw threads. A recently developed method by which the seats are built up by bronze-welding promises a number of advantages over the cast-bronze type of construction. It is the purpose of this article to describe the procedures employed for the bronze-surfacing operation, and to outline briefly the benefits which result to both the valve user and valve manufacturer through this new method of construction.

In the first place the quality of brass or bronze used for the cast-bronze seats is confined to a soft cast-brass or bronze which can be securely rolled into place. The life of such material may be considerably less than could be obtained from a harder and more wear-resisting material. Some trouble may be experienced from these rolled-in seats becoming loose or detached in service.

There are also objections from the valve manufacturer's standpoint to this type of construction, among which are delays occasioned in delivery of the cast-bronze seats and some difficulty experienced in obtaining perfect castings. Sometimes blowholes or other defects in these cast bronze seats are not discovered until the machine work necessary before rolling is completed, and in some cases they show up only after the seat has been rolled into position and the final machine work is being done. This, of course, occasions considerable extra labor in removing the seat and replacing it with another casting.

It is thought, too, that the maintenance cost of valves in which the seats have been built up by bronze-welding may be considerably

A paper presented at the Canadian Section Meeting at Toronto by G. G. Routledge, Engineer in Charge of Water Distribution, City of Toronto, Canada; and by W. A. Duncan, Manager, Process Service, Dominion Oxygen Company, Ltd.

less than for those with cast seats. Damaged or worn seats discovered in service can be readily repaired by building up the seats by bronze-welding. After they have been re-machined they should be just as satisfactory as when new. This procedure, it is thought, can be followed with less delay than would be occasioned with the cast type seats where special castings would have to be obtained.

Procedure for Bronze-Welding

Since this method of constructing the seats for gate valves for water mains is new, a detailed description of the procedure adopted, with particular emphasis on the bronze-welding of the seats may be of interest. The procedure described will apply to most standard types of gate valves for water mains.

The bodies and gates of the valves are machined with a flat face where the seat is to be built up, this face being machined approximately $\frac{3}{32}$ to $\frac{1}{4}$ in. below the finished dimensions depending on the size of the valve. Figure 1 shows the body of a 12-inch valve in which the flat machined face has been prepared for welding. It will be appreciated that the preparation of the seats for welding is simpler than that previously required where rolled-in seats were to be used.

A further recent development, in connection with the preparation of the casting for bronze-welding has conclusively proved that the straight cast-iron surface, prepared by sandblasting with metal shot, forms a perfectly satisfactory base for bronze-welding. In the future, therefore, consideration can be given to depositing the bronze on the valve bodies and valve gates directly onto the sandblasted cast surface; thus eliminating the necessity of first machining these surfaces. This procedure has been carefully studied, comparative samples having been made, and tests definitely indicate that the results obtained from a deposit on the sandblasted surface are equal —if not in most cases superior—to the deposit on a machined surface. The reason for this is largely due to the tendency to smear graphitic carbon over the surface during the machining operation, which makes it a little difficult to tin the bronze onto this surface. On the sandblasted surface, however, the free graphitic carbon is not so evident.

The body is then placed on a turntable jig (jig can be seen in fig. 8 below) and preheated with a gasoline-air blowtorch to about 700°F. On the smaller valves, such as the 4- and 6-inch sizes, the bodies may be preheated with the oxy-acetylene blowpipe. How-

ever, it is believed that the most satisfactory arrangement is to have proper facilities for preheating the bodies of the valves and provision made to reheat these to uniform temperature and cool slowly after the bronze-welding.



FIG. 1



FIG. 2

FIG. 1. 12-inch Gate Valve Casing showing the seating surface machined in preparation for bronze-welding

FIG. 2. Operator Bronze-Welding One of the Seats in a 12-inch Gate Valve Casing. Observe the jig used to hold the casing at the proper angle to allow it to be rotated during the welding; also the gasoline-air burner in the lower right hand part of the picture, which is used for preheating; and the air line at the upper right hand corner of the picture, which blows away the fumes from the operator.

This turntable is also used to rotate the valve body during the welding operation. Some of the details of this operation can be noted in fig. 2. The jig holds the valve body at the proper angle so that the machined face on which the bronze seat is to be deposited will be horizontal or at an angle which will allow the operator to deposit the metal on a slight upward incline.

After the body is preheated to about 700°F., it is protected with a sheet of asbestos as shown in fig. 2. The bronze is then applied in a single pass, using a special oxy-acetylene blowpipe having a long gooseneck stem specially designed to allow ready access to the interior of the body of the valve. The actual bronze-welding operation can be seen in fig. 4. After the first seat has been completed,



FIG. 3

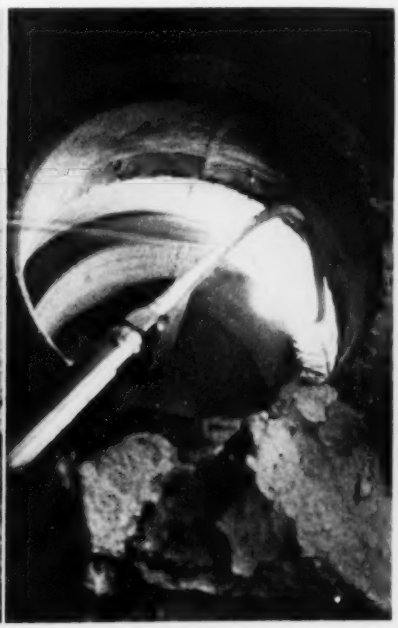


FIG. 4

FIG. 3. Operator Bronze-Welding Seats on a 6-in. Valve Body. Note the jig which holds the valve, the sheet metal casing used to retain the heat, and the flux holder. The left foot of the operator is used to rotate the jig during welding.

FIG. 4. Close-up View Showing the Depositing by Bronze-Welding of a seat in a 12-inch gate valve casing. Observe the special long stem blowpipe used for this operation.

the valve body is reversed and the second seat is built up in the same manner without any additional preheating. Figure 5 illustrates the body after the seats have been built up with bronze, and fig. 6 shows the same body after the bronze seats have been machined.

An important detail in the actual bronze-welding is the use of high-strength, low-fuming bronze rod, $\frac{3}{8}$ in. in diameter. Also a

simple flux holder has been constructed, as was illustrated in fig. 3. With this device, bronze-welding flux is made into a solution by dissolving powdered flux in hot water, and the rod is coated with flux by dipping it in the solution—about 100 lb. of $\frac{3}{8}$-inch rod can be completely coated with about 3 lb. of flux in approximately 10 min. A rack is provided on the outside of the flux holder in which to stand the rods after dipping. Considerable time is saved in the actual



FIG. 5



FIG. 6

FIG. 5. 12-inch Valve Casing with Bronze-Welded Seats, before machining
FIG. 6. 12-inch Valve Casing with Bronze-Welded Seats, after machining

depositing of the bronze, particularly in the bodies, due to the fact that the rod does not have to be continually removed for fluxing.

The gates of these valves are treated in a similar manner, the faces being machined approximately $\frac{3}{32}$ to $\frac{1}{4}$ in. below the finished dimensions. They are then placed on the same turntable, preheated to the same temperature, and the bronze applied in a single pass. This operation is illustrated in fig. 7.

On the 4-, 6-, and 12-inch valves, bronze is deposited on the seats

and gates to a depth of approximately $\frac{3}{16}$ in. On larger valves this depth of deposit is slightly greater in order to allow the seats to be turned down to leave a finished depth of bronze of about $\frac{3}{32}$ in. In this connection it should be noted that existing specifications, in most cases, show a cast shoulder of $1\frac{1}{4}$ in. on which the bronze seat is to be placed. The specifications also require the full width of $1\frac{1}{4}$



FIG. 7



FIG. 8

FIG. 7. Bronze-Welding the Seats of a Gate for a 12-inch valve. The jig allows the gate to be rotated during welding.

FIG. 8. Bronze-Welding Seats on Gate of a 6-inch valve. Note the additional holder to center the jig for holding gates.

in. for the finished bronze seat. In order to deposit the minimum depth of bronze necessary for machining to the required finished dimensions, it has been found that if the width of the cast seat is between $1\frac{1}{2}$ and $1\frac{5}{8}$ in. a faster deposit is possible and less bronze is required. Frequently valves 4 in. in diameter and under are fitted with gates of bronze which require machining only.

Time and Materials Required

Table 1 gives some details of the materials and time required for the building-up of seats on gates and bodies of 4-, 6-, and 12-in. valves. It should be noted that these figures are only approximate and the

TABLE 1

Materials and Time for Building-up

VALVE BODY

SIZE	APPROX. WEIGHT OF DEPOSITED BRONZE	ACETYLENE CONSUMPTION	OXYGEN CONSUMPTION	TIME DEPOSITING (INCLUDING PREHEAT)	TIME MACHINING (SEATS ONLY)
inches	*lb.*	*cu.ft.*	*cu.ft.*	*hr.*	*min.*
12	7.5	60	60	2	35 (before welding) 35 (after welding)
6	4.5	30	30	1	30 (before welding) 30 (after welding)
4	2.5	20	20	¾	25 (before welding) 25 (after welding)

VALVE GATE

SIZE	APPROX. WEIGHT OF DEPOSITED BRONZE	ACETYLENE CONSUMPTION	OXYGEN CONSUMPTION	TIME DEPOSITING	TIME MACHINING
inches	*lb.*	*cu.ft.*	*cu.ft.*	*hr.*	*min.*
12	7	65	65	1	25 (before welding) 25 (after welding)
6	4	28	28	½	20 (before welding) 20 (after welding)
4	Solid Bronze				

welding time unquestionably can be greatly reduced after the operators acquire more skill.

The seats on cone valves can readily be constructed by a welded-bronze deposit. Figures 9, 10, 11, and 12, illustrate a 48-in. diameter automatic cone type valve on which the seats have been built by a deposit of bronze welded to the cast steel. On valves of this type,

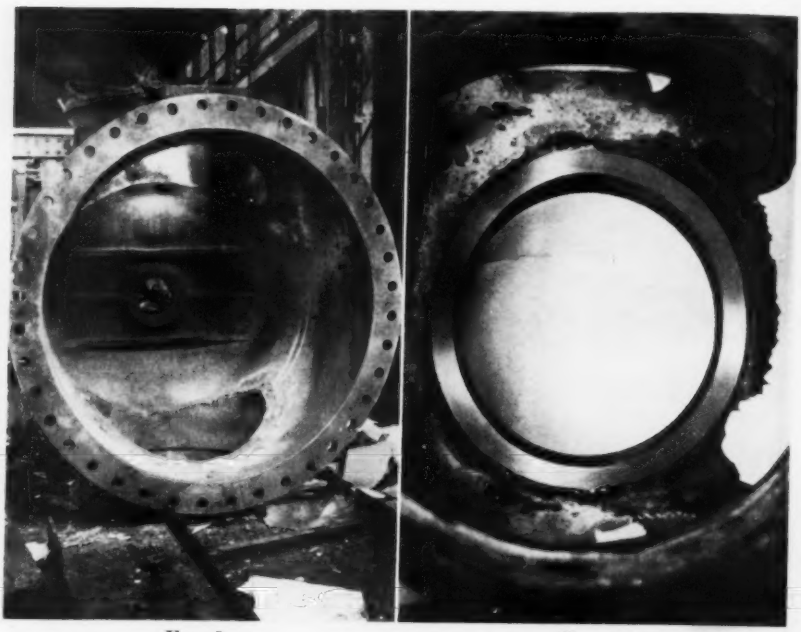


FIG. 9 FIG. 10

FIG. 9. General View of Cast Steel Casing of an Automatic Cone Valve, showing seats built up by bronze-welding, before machining
FIG. 10. View of Seat on Casing after Machining

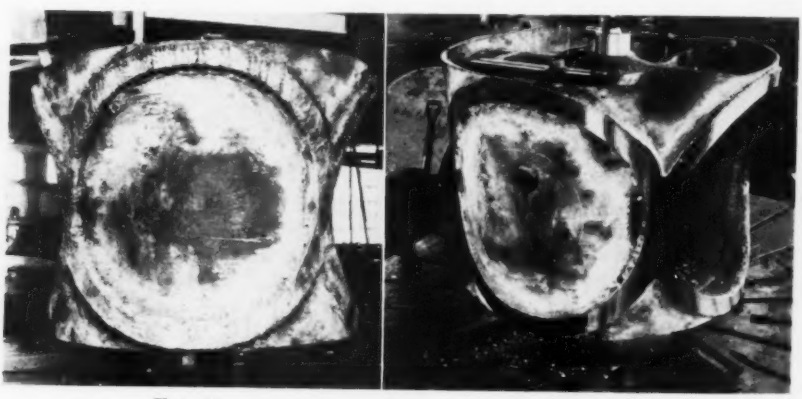


FIG. 11 FIG. 12

FIG. 11. Cast Steel Cone or Plug for an Automatic Cone Valve with four seats built up by bronze-welding
FIG. 12. Cone of Valve with Built-up Bronze Seats, after machining

the complete casing is preheated to from 600 to 800°F., using both a charcoal fire and gasoline-air blowtorches.

The materials used for the building-up of the two complete oval seats shown in fig. 9 are as follows:

Bronze Welding Rod (¼-in.)	120 lb.
Oxygen	3,300 cu.ft.
Acetylene	3,100 cu.ft.
Flux	10 lb.
Asbestos	4 rolls
Fuel oil	20 gal.
Charcoal	20 small bags (paper)
Labor (welders)	171 man-hours
Carbon plate	1 (1 x 6 x 30 in.)
Weight of casting	4½ tons

The plug of the valve is handled in a similar manner. Figures 11 and 12 show the plug before and after machining. It is to be noted that the plug has four oval seats whereas the casing has only two. It should be noted also that an excellent deposit is obtained by bronze-welding as shown in the seats after finishing (figs. 10 and 12).

While valves that have been manufactured by this procedure have not been in service long enough to give a reliable comparison with those having cast rolled-in seats, it is confidently expected that additional years of service will be obtained from these valves. The two main reasons for this, it is believed, are:

1. The seats built up by bronze-welding become an integral part of the casting itself. This should eliminate troubles experienced with the rolled-in type of seat as mentioned previously.

2. The bronze rod used for building up the seats is a somewhat harder and definitely more wear-resisting material, which should increase the life of the valves.

The writers believe this marks a distinct advancement in the methods of construction of valves for water mains.

ABSTRACTS OF WATER WORKS LITERATURE

Key. 31: 481 (Mar. '39) indicates volume 31, page 481, issue dated March 1939. If the publication is paged by issues, **31:** 3: 481 (Mar. '39) indicates volume 31, number 3, page 481. Material enclosed in starred brackets, ★[ ]★, is comment or opinion of abstractor. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene (British)*; *C. A.—Chemical Abstracts*; *P. H. E. A.—Public Health Engineering Abstracts*; *W. P. R.—Water Pollution Research (British)*.

NORTH AMERICAN WATER WORKS

Los Angeles, Calif., Board of Water and Power Commissioners, Annual Report, Year ending Jun. 30, '38. Water works section of report submitted by H. A. Van Norman, Chief Engr. and Gen. Mgr., Wm. W. Hurlbut, Engr. of Water Works, and others. Water supplied for both irrigation and general use. Rainfall for yr.—23.43″, 53.8% above normal. Purchase of c.i. pipe amounted to 3461 tons, equivalent of 35.06 mi. of main. Av. cost of pipe in yds. or trenchside—$53.82 per ton, increase over $50.95 of previous yr. Approx. 1031 tons (2.88 mi.) of welded steel pipe bought, price—$91 per ton. 28,743 mil. gal. water pumped by 45 pumping stations; domestic consumption 170 mil. gal. per day; equals 121 g.p.d. per capita for the estimated 1.4 million pop. served. Detailed reports given for operation and maintenance Los Angeles Aqueduct; Distribution, Construction and Operation Division; Pumping Plants and Reservoirs; Ground Water Surveys and Development; Meters and Services; Water Sales; Sanitary Eng. Div.; etc. Dept. has 271,082 meters in use, increase over '37 of 6737; during yr. 0.18% were taken out and reported as not operating, 49% of which were damaged by hot water. Total of 14,087 meters repaired at unit cost of $4.908; 22,942 tested at $0.173. Active domestic services number 259,975. Length of dist. mains and conduits—4052 mi., increase of 42.13 mi. System has 21,034 hydrants. Sanitary Div. reported analysis of 25,531 field samples, and 42,494 lab. analyses of which 29,471 were bacteriological. Automatic chlorine control used in many cases. Cross-connection survey resulted in elimination of dangerous connections. Bacterial quality: 2384 total samples untreated gave results of which 197 showed 3 or more tubes positive (8.26%) and 1180 of the 11,920 portions were found positive (9.90%). On treated waters 25,771 samples run, 2377 portions of 128,855 were found positive (1.84%). Research being carried out to improve media and expeditite results. Av. chemical results of city supply: alk.—140 p.p.m., Cl—24, CO_2—1.3, color—9, turb.—5, pH—7.9.—*Martin E. Flentje.*

Development of Victoria's Municipal Water Works. G. M. IRWIN. Can. Engr. **77**: 11: 6 (Sep. 12, '39). History of supply is reviewed and present system described in some detail. First piped supply developed about 1860 and in early days slow sand filters were employed. In '13–'15, Sooke Lake supply was developed, which consists of 3400-mil. gal. impounding reservoir, 17 mi. from city, 42″ reinf. concrete conduit to Humpback Reservoir, 10 mi. from city, and 36″ riveted steel pressure main to distr. system. In '25, city acquired Goldstream system of Esquimalt Water Works Co., deriving its supply from series of natural lakes, 16 mi. from city. Both are gravity systems and are operated separately but interconnected. Av. daily consumption is 9.4 m.g.d. for estimated pop. of 62,000, equivalent to daily per capita consumption of 151 gals. Peak demand is 19 m.g.d. All services are metered. Water of both supplies is low in total solids and hardness is neglible. Pathogenic bacteria are absent. —*R. E. Thompson.*

Denver, Colo., Annual Report of Board of Water Commissioners, '38. GEO. F. HUGHES, Exec. Sec'y. and D. D. GROSS, Chief Engr. Pop. served 345,000. Water supply largely from melting snow in mountains. Including sources on opposite side of continental divide, sources are South Platte and Fraser rivers, Bear and Cherry Creeks. Storage res. are Antero with capac. of 10,843 mil. gal.; Eleven Mile Canon—26,693, Cheesman—25,763, and Soda Lakes (30% owned)—653; operating res. known as Platte Canon, Marston Lake, Ralston, and Long Lake with total capac. of 10,482 mil. gal.; grand total of all water in storage including distribution reservoirs 74,510 mil. gal. Length of raw water transmission conduits—33.7 mi., filtered water—91.3; distribution system—769 mi., has 4513 fire hydrants. Dept. employees number 495. '38 revenue $2,694,515, '37—$2,695,712; '38 expenses—$785,453; '37—$765,340; '38 interest expense—$1,005,941, '37—$845,041; '38 net income $315,419, '37—$610,123. Municipal bonds outstanding—$25,204,600; book value of property —$42,056,483, on which the cost per mil. gal of consumption for interest at 4% plus depreciation plus maintenance and operation is $150.68. System has 73,491 service connections with 933 added during yr.; 2428 active meters, 18.8% of total revenue coming from metered sales. Comparison given of av. total cost of operation and maintenance (1) wood-stave and (2) reinf. concrete conduits, equals for (1) $478.36 per mi., (2) $213.46. Plant has slow and rapid sand filters, and infiltration galleries. Capac. of 4 filter plants are, Kassler (slow) 30 m.g.d., Marston Lake, South Side (rapid) 21 m.g.d., and Marston Lale North Side (rapid) 64 m.g.d.; Cherry Creek (infiltration) 3 m.g.d., Moffat (rapid) 56 m.g.d. Total consumption '38—20,629 mil. gal., daily av. 56.519 mil. gal. equals av. of 160 gal. per cap. per day for year with rainfall of 19.46″; max. days consumption—130 mil. gal. Av. total hardness tap water from South Platte source—95 p.p.m.; HCO_3—82; total dissolved solids 149; pH—7.66; temp.—15.2°C. Water from Moffat diversion source—total hardness 50; pH —7.3. Total of additions to water plant during '38—$11,850,043.—*Martin E. Flentje.*

Little Rock (Ark.) Water Works, Second and Third Annual Report, '37–'38. Municipal water plant operated by Board of 3 members—H. L. THOMAS, Chairman; L. A. JACKSON, Operating Mgr. Water from new mountain supply,

Lake Winona (capac. 14 billion gal.—35 mi. west of city) and Alum Lake Dam (capac. 92 mil. gal.) first flowed to city on Feb. 17, '38. Pop. served—107,245 estd. Total water production—in '37—2657 mil. gal.; in '38 2559 mil. gal.; per capita consumption—'37, 50 g.p.d.; '38, 51 g.p.d. Total operating revenue —'37, $592,698; '38, $611,893; increase of $19,195. Total operating expense—'37, $178,047; '38, $171,465. Net income for '37—$252,798; '38, $197,702. New 8 m.g.d. filtration plant also put into service in Feb. '38. Sedimentation and coagulation in 3 basins; 2 for natural settling with capac. of 5.0 mil. gal., 1 coag. and storage—5.5 mil. gal., and 5.0 mil. gal. covered clear well. Filters in use—old concrete, 14—½ m.g.d. units; new, 4—2 m.g.d. units. Total cost all chemicals '38,—$10,196; per m.g.—$3.98; '37—$19,881, $7.53 (former supply). Character new supply—raw turbidity (av., max., min.,—'38) 9, 28, 2; alkalinity —17, 21, 13; total hardness—15, 20, 12; total hardness city—after treatment—33, 44, 20; color raw—34, 50, 0; pH (plant effluent)—8.9, 9.9, 7.5; total count, raw av.—156, plant eff.—3; coliform index, raw—264; plant eff.—0.02. Dist. system has 227 mi. of mains with 1596 valves and 958 hydrants. Total meters —18,015. Total cost of water production—13.08¢ per 1000 gal., rec'd.—22.38¢, profit—9.30¢. Property valued at—'37—$7,217,667; '38—$7,434, 473; total bonds outstanding—$6,502,000.—*Martin E. Flentje.*

Two Way Radio Between Dam and Filtration Plant. ADOLPH O. GOLDSMITH. W. W. Eng. **92:** 326 (Mar. 15, '39). Two way radio costing $3900 installed for communication between Little Rock, Ark., filtration plant and res., 35 mi. away. Savings consisted in original cost, telephone system estimate being $8000, and in yearly maintenance costs, $1200 having been estimated for telephone system as against $250 (actual) for radio. Operates on 41 megacycles; found satisfactory.—*Martin E. Flentje.*

Protecting Chicago's Water Supply. SAMUEL N. KARRICK. Civ. Eng. **9:** 547 (Sep. '39). Both cholera and typhoid fever were very prevalent in Chicago during 1849 and 1850. The prevalence of typhoid and other waterborne diseases reached an alarming state. In 1885 a great flood occurred which reversed the flow in the Chicago River and carried great quantities of sewage and accumulated sludge into Lake Michigan. In 1889 the Sanitary District was organized and, in 1899, when the Main Channel was nearing completion the Secretary of War issued an operating permit to the District. In 1925 the District applied for permission to divert 10,000 c.f.s. from L. Michigan and was allowed to take 8,500 in addition to the normal water pumpage of 1,500. The Supreme Court, in its 1930 decree, enjoined the District from diverting water in excess of 6,500 c.f.s. in addition to the domestic pumpage, with a max. at the end of '38 of 1,500 c.f.s. To prevent reversal of the Chicago R. the District was granted permission to install a gate at the mouth, with a lock to care for navigation. The lock was officially opened on Sept. 7, '38. It has proven satisfactory for the twofold purpose of navigation and sanitation.—*H. E. Babbitt.*

Efficiency in Water Service. W. W. DEBERARD. Eng. News-Rec. **121:** 302 (Sep. 8, '38). Water supply management as practised by Indianapolis

Water Co., largest privately owned system in country, is discussed. Supply derived from White R. at Broad Ripple Dam and conveyed through 6.7-mi. canal to slow and rapid filters, head in canal being utilized to pump filtered water. Field of 15 wells on Fall Creek is employed only in case of emergency. Standard procedures have been developed for practically every repetitive item involved in operation. For example, 5 standard colors of paint are employed, each with definitely designed place. Water analyses records date back to 1896. Nearly every requirement of underwriters regarding pressure and distribution for Class 1 rating is fulfilled. Maintenance of good public relations is stressed.—*R. E. Thompson.*

Increasing Canton's Ground Water Supply With a New Well. C. S. BOLENDER. Pub. Wks. **69:** 12: 22 (Dec. '38). Canton, O., pop. 120,000, has had difficulty obtaining water supply of sufficient capac. until Water Comm. of engineers was appointed in '36. Capac. of 16 m.g.d. increased to 25 m.g.d. by installation of new wells drilled on field known as Harrisburg field, 6 mi. NW. of city. First new 30″ well drilled in this field in '37, 161′ deep with water standing at 28′; capac. 6 m.g.d. with drawdown of 8′. Second well 200′ also has 6 m.g.d. cap. with 8′ drawdown. No treatment used, av. consumption of city in '37, 12.68 m.g.d., a per capita av. of 92 g.p.d.—*Martin E. Flentje.*

Private Water Company Practices—Consumer Relations and Maintenance Methods of West Virginia Water Service Co., Charleston, W. Va. NATHAN N. WOLPERT. W. W. Eng. **92:** 1308 (Oct. 11, '39). Operation practices reviewed of company supplying territory in and around Charleston, W. Va. with pop. of 125,000 to 150,000. Practically entire territory metered with majority of meters located at curb. Various practices in handling consumers complaints, laying pipe, hydrants etc. discussed.—*Martin E. Flentje.*

Water Works Improvements at Charlotte, N. C. J. B. MARSHALL AND C. S. RAWLINS. W. W. and Sew. **86:** 83 (Mar. '39). Charlotte, N. C., authorized a bond issue of $1,365,000 for improving the waterworks. Old raw water pumps were replaced with three new units having a total of 30 m.g.d. capac. Valves and wiring were brought up-to-date and a new force main installed. Three elevated storage tanks totaling 2 m.g.d. were installed. Filtration plant capacity doubled. Mixing time increased from 6 to 40 min. Mixing comprises "flash" air agitation, vertical shaft mixing, and flocculators, in sequence. Settling capacity was increased. Three new filters added. New control building houses chemical storage and feed equipment, laboratory and offices. Treatment includes chlorine, ammonia, aeration, activated carbon, soda ash, lime, and alum. Clear water storage space enlarged. One new 10 m.g.d. high service pump was added. Wash water tank with new wash water pumps was also provided.—*H. E. Hudson, Jr.*

Dep't. of Water Supply, Ridgewood, N. J. J. A. CARR. W. W. Eng. **92:** 1106 (Aug. 30, '39). Municipally owned since '21, Ridgewood Water Dep't. (author—Sup't.) serves also adjoining Midland Park and Glen Rock, with an additional supply for portion of Wyckoff. Pop. served is approx. 25,000,

being served through 115 mi. of dist. mains. Territory largely one of homes with lawns and gardens resulting in marked increase in consumption during summer months. Supply entirely from wells, all double cased and sealed into rock, av. 275′ in depth with capacity from 100 to 375 g.p.m.; number in use—23, with 15 equipped with deep well turbines, all electrically operated. System has 6 pumping stations and 5 steel storage tanks, each equipped with long distance water level recorder. Mains laid by dept. forces, all 6″ or larger; laid on north or west side of streets 5′ from curb line with min. of 4½′ of cover. System contains 1750 valves all of one type and make; 600 fire hydrants also standardized as to type and mfgr. Complete service connections made by dep't. with owner paying in advance flat charge per foot for distance from curb line to house based on av. cost of services for yr. previous. Meters all of one make, tested in own shops with no meter allowed to remain in service more than 5 yrs. without test; meters over 2″ tested in place twice each yr. Two 5-ton and four ½-ton trucks used. Complete operation and cost records kept, also records of rainfall and temp. Illustrations show skillful and effective landscaping in grounds around various stations.—*Martin E. Flentje.*

Story of the Boston Broadside. M. N. Baker. Eng. News-Rec. **123:** 290 (Aug. 31, '39). Early history of Boston's water supply is discussed briefly. In 1652, a few Boston householders brought spring water to their homes, thus establishing first waterworks in America. Boston was incorporated as city in 1822 and from outset there was strong demand for public ownership and support for practice of going far enough afield for water to make filtration unnecessary, policies which have been rigidly adhered to ever since. Broadside referred to in title was against private ownership and resulted in vote of 2107 to 136 in favor of public ownership in 1836.—*R. E. Thompson.*

Hamilton Report for 1937. Anon. W. W. Inf. Exch., Canadian Sect., A. W. W. A., **2:** E: 1: 1 (Jan. '39). Following data were taken from report of W. L. McFaul, City Engineer, Hamilton, Ont. Pop. 154,052. No. of hydrants 2,853, or 11 per mi. of mains. Av. amount of water pumped 20.1 m.g.d., or 130.4 gals. per capita (Imperial gals.). Av. pressure on mains 82 lbs. per sq. in. Cost of main repairs averaged $48.30 per mi. Chemicals used in purification process, in lbs.: alum 72,817, activated carbon 232, chlorine 36,057, ammonia 3,741, ammonium sulfate 23,200. Length of filter runs varied from 6 hrs. 54 min. to 48 hrs. Filters are washed at 8′ loss of head. Wash water percentage 2.6. Max. turbidity of raw water 400 p.p.m.—*R. E. Thompson.*

Our Public Water Supplies. Octavio Marcano. Puerto Rico Hlth. Bull. **111:** 3: 71 (Mar. '39). It is pointed out that there is an urgent necessity for a sufficient supply of potable water in Puerto Rico to: (1) protect the public health; (2) succed in tourist enterprise; (3) certify water for interstate traffic; (4) supply water within the U. S. Treasury Dept. standards for the Army and Navy. Since watersheds are heavily populated (506 inhabitants per sq. mi. of territory) and quality of both surface and sub-surface supplies is impaired, adequate treatment is the only recourse. At present, of an urban pop. of 607,457, there are 369,112 served with filtered and chlorinated water. 18,411

more will soon be served with completely treated water by the new plant at Guayama. An additional 23,749 receive water from supplies having emergency chlorinators. The balance receive untreated water. A rural pop. of 1,197,018 has no public water service. Due to works becoming obsolete, lack and diversion of water revenue funds, growth of communities, limitation of reserve fund withheld by the Public Service Comm., and failure of governments to conceive the magnitude of the problem and their responsibility, there is very little likelihood of obtaining sufficient and safe water supply systems. It is recommended, therefore, that all water supply and purification services be consolidated under one Insular Bureau, Authority, or Cooperative similar to the Irrigation Service. This authority should be empowered to control, administer, collect, construct, improve, maintain, and treat all public water supplies. The necessary legislation will have to be approved in order to be able to solve this vital problem properly.—*P. H. E. A.*

Inventory of Water Supplies. ANON. Eng. News-Rec. **123:** 414 (Sep. 28, '39). Data compiled in nation-wide survey from information furnished by state sanitary engrs. is given. Data for 48 states and District of Columbia include no. of people and communities served by water systems, ownership, sources of supply, and detailed tabulation of treatment facilities. Two-thirds pop. of U. S. is served by community water systems. There are 12,750 waterworks for 13,293 communities enjoying central supply and distr. facilities. Only about 27% of systems are operated by private companies: on pop.-served basis, private utilities handle only 11% of business. About 85% of 81,200,000 people served receive water that has been treated for health protection, quality improvement or both. Chlorination is practised at only 4015 plants. Filtration is provided for at 2188 plants, of which only 97 are of slow sand type. Taste and odor control is practised at 1187 plants, Fe and Mn removal at 417 and softening at 484. About 9100 systems employ groundwater as compared to approx. 3300 which derive their supply from surface sources. —*R. E. Thompson.*

SOUTH AMERICAN WATER WORKS

Provision of Water Supplies and Drainage. Domestic and Industrial Installations. R. NIRENSTEIN. Bol. Obras Sanitarias Nacion (Buenos Aires) **2:** 303 ('38). Reviews legislation in the Argentine Republic dealing with the provision of water supplies and the control of pollution of surface and ground waters by sewage. Water supplies and means of sewage disposal for single houses are being replaced by collective systems. In the 18 yrs. following the enactment of legislation requiring the provision of water supplies for towns with over 3,000 inhabitants, and sewage disposal systems for towns with a population greater than 8,000, 39 communities have constructed the required works. There are 54 Sanitary Districts under the Obras Sanitarias de la Nacion. Much work remains to be done in surveying sources of water and studying the best means of obtaining supplies. Some water supplies are treated by chlorination alone; the provision of more complete treatment depends upon the quality of the raw water. Various methods of treatment are outlined. The necessity for treating sewage before it is discharged is recog-

nized. As early as 1891 a law was passed prohibiting the discharge of sewage into rivers which serve as sources of water supply. The laws controlling the discharge of sewage and trade wastes are described with special reference to the La Plata river, where the dilution of any wastes discharged is very great. Advances in sanitation technique have necessitated the revision of the regulations concerning water supplies and sewage disposal; the revised regulations are now under consideration by the Government.—*W. P. R.*

The Hygiene of Domestic Water Tanks and Filters. ANON. Bol. Obras Sanitarias Nacion (Buenos Aires) **3:** 573 (Jun. '39). Water from the mains in the Buenos Aires system has to be pumped to storage tanks in buildings more than one story high. Since in the majority of cases the design of the domestic tanks does not provide adequate protection to the potable water delivered at the building entrance, it has been necessary to require the use of individual Berkefeld type filters as a means of safeguarding the health of apartment house residents. Although there is a gradual replacement of old storage tanks with others of approved design, there are still some sixty thousand inadequate installations to be replaced. For this reason, the use of household filters cannot be dispensed with for some time. Realizing that the improper use of these filters renders them useless and in some cases dangerous, specific instructions are given for their frequent cleaning and disinfection.—*J. M. Sanchis.*

Water Supply for the City of Rio Gallegos, Santa Cruz, Argentina. CARLO LUIS GOTTIFREDI. Bol. Obras Sanitarias Nacion (Buenos Aires) **3:** 2 (Jul. '39). This rapidly growing city of about 4000, capital of a large territory, owns the most southerly public supply in Argentina. It is favorably situated on the estuary of the Gallegos River and is the center for an immense sheep-raising district. Water is taken from gravel beds underlying the Rio Chico, a minor river, at a point 5 km. from the city. It is pumped by Diesel engines from two filtering wells to an elevated concrete tank of 120 cu. m. capac. from which it flows to the city through a main 4750 meters long by 220 mm. diam. at a pressure of about 23 meters. Distribution piping totals 25,783 meters; '38 consumption totalled 143,305 cu. m. Service pipes of unprotected galv. iron are rapidly attacked externally; protective coatings are now applied with satisfactory results. Repeated analyses have shown the water to be of excellent quality and not in need of treatment. The Patagonian climate is dry and cold and therefore healthy. Strong WSW. winds blow constantly from the Atlantic to the Andes, causing the intervening country to be bleak and bare looking; but the great Andean lake region is of surpassing beauty.—*Frank Hannan.*

Remodelling and Enlargement of the Water Supply of the City of Paraná, Entre Rios, Argentina. ANECTO J. BOSISIO. Bol. Obras Sanitarias Nacion (Buenos Aires) **3:** 25 (Jul. '39). This actively growing city, the state capital and at one time the federal capital, is built on the well-known bluffs of the tremendous river after which it is named and from which it takes its supply. The new intake has been installed in the stream at a point where erosion and deposition are least active. The river level fluctuates through a range of 7.5

meters. The water flows by gravity through a c. i. main 70 m. long and 800 mm. diam. to the three low-level pumps, each delivering 600 cu. m. per hr. against 105 m. head, situated inland at foot of the bluffs in a sunken circular concrete pit. Motors are housed in an octagonal building overground, resting on pump pit. The delivery main to the purification plant is over 5 km. long and 750 mm. diam. Water as it arrives at the plant is dosed with coagulant in a mixing chamber, passing then by hydraulic jump into sedimentation basins. The settled water is delivered on to the 4 rapid sand filters of standard type, each 60 sq. m. in area, with perforated tube bottoms and 800 mm. of sand of eff. size between 0.35 and 0.45 mm. and unif. coef. not greater than 1.7. A clear well, reservoir and pressure pumps with chlorination equipment, and office buildings are included, the total contract cost amounting to $551,759. (Argentine).—*Frank Hannan.*

Public Water Supplies of Uruguay. ANTONIO PELUFFO. Anales facultad quim. farm. (Montevideo) **2**: 6: 92 ('38). Analyses of waters from all important sources in Uruguay are given.—*C. A.*

Technical Vocabulary of Sanitary Engineering. ROBERTO F. RECORDER, RAUL FERRAMOLA AND CARLOS E. GIETZ. Bol. Obras Sanitarias Nacion (Buenos Aires) **3**: 469 (May '39). The lack of adequate Spanish words for the translation of foreign technical terms in the fields of engineering and sanitary chemistry, makes it desirable to open a discussion for the selection of a suitable sanitary engineering vocabulary. The authors enumerate the various terms used by different writers for each of the following expressions; hardness, decantation, sedimentation, clarification, chlorination, filter run, pumping, sludge, dosing, baffle, raw water, up and down and around the end circulation, bio-chemical oxygen demand, turbidity, aeration, disinfection, sewage, sewer, sewerage, and industrial wastes. An opinion is advanced as to the most logical word to use in each case, giving reasons for its selection. The attention of technical men in the sanitary engineering field in Latin America is called to the importance of standardizing their professional vocabulary and an appeal is made for their cooperation in the solution of this fundamental probelm. ★[Having struggled with the difficulty of finding proper words with which to express some of the technical terms in Spanish, this abstractor sympathizes greatly with the effort being made by the Argentineans]★.—*J. M. Sanchis.*

EUROPEAN WATER WORKS

Water Supply. W. J. E. BINNIE. Wtr. and Wtr. Eng. (Br.) **41**: 439 (Aug. '39). (*Presented before Royal Sanitary Inst.*) About 95% of the population of England and Wales now provided with a public water supply. The time is not far distant when it will be provided to all. Use of rapid sand filtration preliminary to slow sand filtration has a most important effect in reducing cost of filtration. Not necessary to use coagulants and the slow sand filter can be operated at 3 to 4 times normal rate. In future rivers will constitute the principal sources of water supply because available reservoir sites are almost exhausted. Gross surface pollution is fortunately decreasing.—*H. E. Babbitt.*

Water Supply in Relation to Municipal Trading. N. J. PUGH. Wtr. and Wtr. Eng. (Br.) **41**: 415 (Aug. '39). *From paper before Inst. Of Public Administration (Oxford.)* Of the 40 million persons supplied with water from mains, 30 mil. are served by municipally-owned works and 10 mil. by private enterprises. Advertising is desirable, but, as used, it is usually negative, requesting consumers to use less of the product. Principles to be emphasized in management include: adequate and pure water supply; the enterprise is not a monopoly; all persons who desire and can pay must be supplied; fire protection must be furnished; water may be supplied for any and for all purposes. An organization chart is given showing many technical posts which may be dispensed with in smaller works, engineers sometimes being called in as consultants. Staff is usually recruited from the lower grades by promotion. Salaries vary with size of the works, in general, for the highest position of Engineer-Manager varying from £ 1,250 to £ 700 annually. Cheapest method of obtaining water is from the company's own shallow well, when it can be obtained as low as 3d per 1,000 gal. (Imp.). The interconnection of neighboring distribution systems is desirable and is one of the few advantages coming from A. R. P. activities. The basic principle for fixing water rates is that "the domestic water rate shall be payable according to the *annual value* of the tenement supplied." As the "annual value" and "domestic use" are not fixed standards difficulties are encountered in fixing rates. The basis of charges for industrial supplies is usually by meter, the rates being fixed on a sliding scale. Payment for water is not extracted from the consumers in proportion to their direct benefit from the service but in accordance with their ability to pay as measured by the value of the premises they occupy.—*H. E. Babbitt.*

Air Raid Precautions. ANON. Wtr. and Wtr. Eng. (Br.) **41**: 427 (Aug. '39). The Metropolitan Water Board (London) has circulated the following advice: air raids will result in waste of water and interference with supplies; consumers are responsible for their premises; they should be prepared to shut off their own water; each property should be equipped with a storage tank, sanitarily protected, in which a supply is maintained, this should be boiled before using; hot water systems must be protected against bursting by drawing the fire, or otherwise; in the event of interruption of supply the greatest economy must be exercised in use of water; consumers should refrain from calling the central office, to avoid clogging the telephone lines at that time; but telephone number and the address of the local water officials responsible for the supply in the consumer's district should be available.—*H. E. Babbitt.*

Sheffield Water Works A. R. P. Scheme. ANON. Surveyor (Br.) **96**: 64 (Jul. 21, '39). An emergency organization has been adopted which involves a large measure of decentralization of material and personnel by the establishment of subsidiary depots. A central water works operative control is established with shelter accommodation for key personnel. To ensure the maintenance of supplies additional emergency repair equipment has been obtained and also additional portable tanks for mounting on trucks. 177 employees had passed through the corporation's anti-gas school by the end of Mar. and 20 men have been trained in first aid.—*H. E. Babbitt.*

Protection of Personnel and Material in a Water System against Attacks in War. F. CH. GEERLING, JR. Water (Netherlands) **22**: 217 (Nov. 4, '38). Since protection of civilians against air attacks in war is placed in hands of the civilian administration, the different industries must find means to protect their plants and personnel. During recent years it has become apparent that non-war industries will be attacked in spite of the Hague Peace Treaty forbidding such actions. Entire population can be considered an integral part of the war machines. Complete evacuation of whole districts is impossible. Keeping food industries intact is important. Since proper distribution and delivery of good water is indispensable to friend and enemy, theoretically pumping stations should not be an immediate target for bombing. Such attitude is as incorrect as the opposite one of attempting to place entire waterworks in bomb proof buildings. For protection of buildings and machinery against exploding bombs of 100 kg. walls of 1½ brick, 60 cm. sand, 50 cm. sand in bags, 30 cm. wood, 30 cm. gravel, 25 cm. concrete, 20 mm. sheet iron or 15 mm. plate steel can be used. Shattering of windows and glass may occur but would not do great damage to machinery. Buildings should not be gas tight, but gas masks should be available. Bombs of 100 kg. exploding on the ground will make a funnel about 23′ deep; bomb proof cellars must be made deep enough and protected sufficiently. During night attacks lights should be covered or windows darkened; pumps can not be stopped on account of fire caused by bombing. The glistening water surface of outdoor filters or reservoirs can be camouflaged by spreading of nets covered with leaves or moss. If bombs with poison gas hit a filter it must be placed out of service; when no mustard gas is used good aeration will be sufficient; with mustard gas chemical treatment is required. Only small quantities of chemical should be stored. Because all technical personnel will be away during war operators should be thoroughly instructed. If part of filtration plant or main lines are destroyed a pressure line should be available to put raw water in the distribution systems. Because certain pumping stations and pressure reservoirs may be destroyed different systems should be interconnected. Public telephones will be occupied and private systems to connect different distribution systems must be available. Proper regulations for closing partially destroyed distribution systems must be worked out locally. Sufficient gas masks, rubber clothing, chemicals, gas detectors and other equipment must be available and personnel trained. Detailed instructions are given for maintenance of mains and plants under war conditions.—*Willem Rudolfs.*

Water Supply in Belgium. L. PERROT. L'Eau (Fr.) **31**: 27 ('38). A description of the development and present condition of the organization for the supply of water in Belgium. The number of communities with distributed supplies increased from 24 in 1865 to 791 in 1935. Effect of this development is seen in reduction of death rate from typhoid from 928 to 22 per million of population. Impetus given to the development of supply by a law passed in 1907 permitting the cooperation of communities for the purpose of supplying water and a law of 1913 forming a National Society for water supply. At the end of '34, 791 of the 2,671 communities of the kingdom, containing about 4.6 of the 8.3 mil. inhabitants, had central water supplies. Tables given showing the distribution of supplies among communities of different types and popula-

tions and the costs of the supplies are discussed. A list of intercommunal associations for water supply and details of the organization of the associations for the Brussels and the Antwerp districts are given.—*W. P. R.*

Dispersion of the Population in Time of War. P. DESCROIX. L'Eau (Fr.) **32:** 76 (Jul. '39). The 21 French departments scheduled to be evacuated in time of war have pop. of 27,365,302; the 41 refuge depts. have pop. of 14,541,754. If only ½ of pop. is moved from evacuated areas, pop. of refuge zone will be increased 50%. Although mobilization will draw up to 25% of pop. from refuge zone, hospitals, mobilization centers, and new industrial establishments will add to pop. load. The refuge regions contain the depts. least well furnished with water supplies, 18.6%, against 44.25% in the evacuated zone. If it were desired to furnish water from public supplies to all refugees accustomed to its use, number of water consumers would be doubled. In absence of satisfactory water supplies, millions of doses of anti-typhoid vaccine should be provided. It is to be hoped that these depts. will rapidly improve their water services if the federal govt. does not do so. Between '34 and '37 the 39 depts. in which in '34 less than 20% of the parishes had water supplies averaged a 3.1% increase, while in the rest of France (average 45.27%) the increase was 7.41%. The hygienic equipment of the west and center of France should be rapidly improved as a part of the passive defense and will have the advantage of constituting an assurance in case of conflict and of improving the material and sanitary conditions of these regions in time of peace.—*Selma Gottlieb.*

Knowing Where One is Going. P. D. L'Eau (Fr.) **32:** 37 (Apr. '39). Although French non-combatants evacuated from Paris and from frontier areas will be protected from bombs and noxious gases, sanitary arrangements must not be neglected. Rural regions have made great strides toward modernization in recent years but in many places water supply is barely sufficient for local population and cannot sustain influx of refugees. Also, at least min. sanitary installations must be provided to prevent epidemics which would be difficult to combat and control. These problems should be studied and solved in advance of the need, and should be a part of the national organization for time of war.—*Selma Gottlieb.*

Department of Water Control (French). A. GUILLERD. Ann. Serv. tech. Hyg. (Paris) ('37). Report of work carried out during '36. Information given concerning the examination and control of the water supplies of Paris and its suburbs, including details of the variation in the quality and yield of each source throughout the year, and operating experiences at the water works. A list of water works and reservoirs is given, and analyses of the waters are given in tables.—*W. P. R.*

Aid of Department of Cote-D'Or to Municipalities. ANON. L'Eau (Fr.) **32:** 8 (Jan. '39). Under act of Nov. 5, '38, loans are available to municipalities for making surveys of sources of water supply and constructing storage facilities and distribution systems. Loans payable over period of 30 yrs. at 6½% for interest and amortization. Amts. available and details of financing given. —*Selma Gottlieb.*

The Upper Rhone and Navigation. ANON. Génie civil **114:** 284 ('39). From Deut. Wasserwirtschaft **34:** 325, (Jul. '39). From the city of Lyons, where it is joined by the Saone, a larger river than itself, down to the Mediterranean, close on 300 km., along a beautiful valley, past cities "old in story," the Rhone has been navigated from time immemorial. It is now proposed to render it navigable from Lyons up to the Lake of Geneva, 219 km., of which 175 is in France, 4 between France and Switzerland, and 40 in Switzerland. The total fall in the French section is 182 meters, making an average slope of 1.04 per thousand. This will be countered by means of ten weirs with locks to correspond, and four side canals will be built as detours where natural channel is unsuitable. In the Swiss section, only one weir, work upon which has started, will be necessary. The total cost of the works on the French section is estimated at 140 millions RM. The only work as yet done in France is at Genissiat, where a fall of 73 meters will be available, and a large gravity dam, 110 meters high at its greatest depth, is under construction. Power will here be generated in 8 units of 60,000 kva. each and the average year is expected to furnish a total of 1800 million kw. hrs. Along the proposed route are situated extensive industries, the chief being lime, cement, and building stone. It is not thought that these alone would enable the canalization to pay for itself, but it is believed that enough of the annual Swiss water-borne imports of about 3,000,000 tons via Dutch ports and the Rhine will be diverted to Marseilles and the Rhone to secure successful operation.—*Frank Hannan.*

The Water Supply of Locarno. G. ALLIATA. Monatsbulletin (Swiss) **18:** 283 (Dec. '38). Water supply for city of Locarno, Switzerland, pop. 10,000, first taken from Remo Spring approx. 12 km. distant from city. Developed by private company in approx. 1895. Capac. of spring normally 100 liters per sec. with practical min. of 25 liters per sec. Temp. of water always about 8° C., total hardness—3 degrees (French) with incrustants of 0.5°. System became public in '04, at that time 100 m^3. capac. dist. standpipe increased to 400 m^3. Later an additional low service standpipe erected with capac. of 700 m^3. Following cold winter of '29, a 0.4 m. diam. 20 m. deep well sunk having capac. of 20 liters per sec. Well water has temp. of 11° C., total hardness of 6° (French) and incrustants of 2°. System contains 20 km. of pipe with 286 valves and 252 hydrants. Yearly water consumption 600,000 m^3.—*Martin E. Flentje.*

Unified Control of Water and Sewage Throughout the River Basin, as Exemplified in the Ruhr District. Marinebaurat a. D. Dr.—Ing. M. PRÜSS, Geschäftsführer des Ruhrverbandes und des Ruhrtalsperrenverein, Essen. Deut. Wasserwirtschaft **34:** 266 (Jun. '39). The water of the Emscher being totally unfitted by pollution for drinking purposes, and that of the Lippe, too heavily mineralized, the entire burden of water supply falls on the Ruhr. The annual pumpage is about 850 millions of cubic meters. The Ruhr problem is therefore two-fold:—(1) to maintain a sufficient flow in the river during the dry season; which is done from the impounding reservoirs of the Ruhrtalsperrenverein, an association formed in 1898; and (2) to keep the Ruhr unpolluted; which is the task of the Ruhrverband. There are three sections; in the lowest, near the mouth, no wastes of any kind may be discharged; a separate channel

for them is provided. Into the next section, only those wastes are discharged which have been purified to the utmost degree known; while in the upper section, the purification specified is somewhat less stringent. Large impounding reservoirs have been introduced to facilitate the completion of self-purification, for which the natural flow was unduly rapid. The water supplies are not taken directly from the river, but from collecting galleries in the underlying Ruhr gravel, which are constructed parallel to the river and about 50 meters distant, to ensure ample filtration; they are therefore "artificial ground water," the supply of which is increased from percolating trenches filled with Ruhr water. The total cost of the various water undertakings in the Ruhr district, similar to and including those mentioned, now amounts to 400 millions RM, all financed by local authorities without Government aid. This is, of course a heavy burden for the water to carry; but on any other basis, the burden would have been much greater. ★[*Explanatory*: The Ruhr industrial district is a conglomeration of cities and towns so closely packed that it is not always easy to discern where one ends and the next begins. Innumerable mine pits, iron works, and factories are dotted in every direction. About 4,500,000 inhabitants are crowded into an area of 1,500 square kilometers, the most densely populated industrial district in Germany, probably in the world. It comprises the whole basin of the Emscher, much of that of the Ruhr, and portions of those of the Lippe and of the Wupper; all of which flow into the Rhine. The heart of the district is the Emscher basin, a strip 70 km. long by about 11 km. broad, with very little slope in either direction and subject, therefore, for centuries, to inundations. The phenomenal industrial growth in the last 50 years had about 30 years ago quite outstripped sanitation, and serious subsidences, due to mines, aggravated the situation. Conditions were growing intolerable when the genius of the late Karl Gerstein indicated how a radical solution was possible, provided that all would unite to act. At an historical meeting of representatives of all the conflicting interests, held in Bochum at end of 1899, his views carried the day. The result was the creation of the Emschergenossenschaft, which cleared up the Emscher by providing a new bed, from 3 to 5 meters below the former level, constructing sewage treatment plants, etc. The vast undertaking took years to plan; work was started in '06 and was not completed till '14. Meantime, in '13, the Ruhrverband, referred to in the abstract, was organized, modeled on, complimentary to, and under the tutelage of, the Emscher genossenschaft.]★—*Frank Hannan.*

Central or Individual Water Supplies. Rudolf Meier. Gas-u. Wasserfach **82**: 598 (Aug. 19, '39). Proponents of central water supplies assume that public supplies are always safe, individual supplies never. Yet both these assumptions are not always correct. Treatment of the problem should not be based on prejudices, but only from the standpoint: How can a safe water supply be guaranteed under all circumstances. In cities and larger villages the central supply is no doubt the most suitable. Individual supplies may be useful as supplements to meet peak loads, where water of certain properties is needed, where increased pressure is required, for economical industrial supplies, and as air raid protection. Individual supplies are also of importance in rural districts. To make individual supplies safe, it is important that they be built by specially trained workers. The movement to train and certify these workers is described.—*Max Suter.*

The Water Supply of the City of Vienna. FRANZ JENIKOWSKY. Gas-u. Wasserfach **82:** 515 (Jun. 15, '39). Ruins of an old Roman water supply built in stone still exist. Later on wooden pipes were used to bring good water from the mountains, but in the Middle Ages and to the middle of the 19th century the water supply was obtained from private wells. From 1836 to 1841 the first central water supply was built, using water from the river Donau through an infiltration gallery. Although this plant was built to furnish 1.6 m.g.d. and was later enlarged to 2.6 m.g.d., it was soon too small for the growing requirements. From 1869–73 the first alpine springs conduit was built. It brought water from large springs for a distance of 56 mi. Tunnels, canals and aqueducts (but no siphons) were used. It is built fully in masonry. Flow is by gravity and ends in a reservoir whose elevation is 240′ above the downtown district. The yield of the springs was quite variable and was soon not enough to supply the demand. In 1878 a groundwater supply in a mountain valley had to be installed to increase the flow during periods of heavy demand. Legal difficulties delayed the use of other springs along this line until after 1890. Most of the infiltration area was bought by the city for the sanitary protection of the springs. Growth of the city caused the construction of an additional groundwater supply, but even this was not enough. Studies of the groundwater conditions in the Donau valley were made, but it was decided to use another group of mountain springs. This second conduit was built in 1901–10. It collects springs from a district of about 25 mi. extent and has a length of 110 mi. Its flow is also by gravity and it ends 260′ above the first conduit. This second line lies mainly in tunnels. Valleys are crossed with bridges or with cast iron siphons. In one steep section with a drop of 620′ a power plant was installed in '24–'25. The water is distributed in the city in four pressure zones, only the highest of these requiring pumping. Twenty storage tanks, including the newest one at Lainz (J. A. W. W. A. **30:** 206 (Jan. '38)) hold useful storage of 100 mil. gal., which is about one day's supply. Consumption varies from 39 to 55 gal. per capita daily and the limit of the supply is already reached, especially as the period of maximum consumption is several months after the period of maximum yield of the wells. Studies for the use of the groundwater underneath the city are under way. —*Max Suter.*

Why Standardization for Water Works? HELLMUT GÖTTING. Gas-u. Wasserfach **82:** 627 (Sep. 2, '39). The advantages of the standardization of parts used in water works are enumerated, mentioning: economical manufacture, reduction in number of parts, simplification of storage, reduction of operating capital, elimination of misunderstandings, reduction of time for delivery, ease in ordering parts for replacement, guarantees for quality and usefulness, and economy of labor and material. A list of the published German standards for materials used in water is attached,— 6 including drafting standards, 6 on arrangement of pipes in streets and buildings, 21 on different types of pipes, 14 on specials, 14 on flanges, 36 on hydrants, valves, manholes, etc., 56 on meters, air valves and fittings, 5 on threads, and 5 on tests. A full list of all the German technical standards (about 6500) is contained in the yearly list of the German Standards Committee, the latest of which is: Normblatt-Verzeichnis 1939. Herausgegeben vom Deutschen Normenausschuss,

Berlin: Beuth-Vertrieb G. m.b.H. 1939. 355 p. DIN A 5, RM4,—brosch. —*Max Suter.*

Note: The list of the so-called "DIN Standards" may be seen at the office of the American Standards Association, 29 West 39th St., N. Y. City, and it is also available in some libraries in the U. S. It has been on sale by the A. S. A. at $2.00 per copy, but the supply is now exhausted and replacement is uncertain. The A. S. A. also has for sale original copies (or photostats) of most of the individual German standards.—*Ed.*

AFRICAN AND ASIATIC WATER WORKS

Water in North Africa. ANON. L'Eau (Fr.) **31:** 130 (Nov. '38). Recent decree by Governor General of Algeria makes 200,000 fr. available for water supply purposes. Dam of L'Oued-Ksob, begun in '31, is scheduled for completion during '38. It is 32 m. high, has capac. of 40,000,000 cu. m., and will permit irrigation of 10,000 hectares in plain of Hodna with farm colony of M'Sila. Since '35 in Mauritania, 981 meters of well drilling have been executed. New program is planned to include 100 new wells in 5 yr. period with total drilling of 1800–2000 meters. From '35 to '37, 89 wells were placed at disposal of the Moors. Wells are of great importance in colonization of this desolate region. *Ibid.* **31:** 143 (Dec. '38). By act of July 16, '38 hydraulic commission has been created to survey hydraulic resources of Morocco, to propose program for next 5 yrs., and to investigate means of carrying it out. *Ibid.* **32:** 6 (Jan. '39). Gen. Noguès, resident general of Morocco has presented to the govt. council a five billion franc program of Moroccan hydraulic projects for next 15 yrs. Increased productivity of country rather than increased taxes will pay cost. At present 45 cu. m. of water per sec. are used for agriculture; plan is to obtain 280 cu. m. per sec., and will enable Morocco to support additional millions of population. Of first importance in plan are building of dams of l'Oum-er-Rebia and Moulouya. Details of financing are discussed. Recent decree of Governor General of Algeria grants to authorized local organizations 250,000 francs for creating and maintaining water systems. In predesert and desert region lying just north of French Sudan, drilling and maintenance of wells is necessary to provide caravans going to Taoudeni for salt. Water lies from 10 to 80 m. below surface of ground. Simple method of drilling and reinforcing wells has been worked out to allow use of readily transportable equipment and supplies. Wells are lined as drilling proceeds with layers of cement reinforced with iron wire (4 to 6 mm.), and similar rings of reinforced concrete of smaller diameter lowered into well after drilling is completed. Curb, watering place and pulley device are provided at each well.—*Selma Gottlieb.*

Rand Water Board (South Africa), 34th Annual Report. Board supplies water in bulk to South African Railway Administration, Transvaal Chamber of Mines and municipalities in districts listed as Krugersdorp (pop.—103,864), Roodepoort (50,290), Johannesburg (537,217), Germiston (99,737) Boksburg (53,269), Benoni (92,281), Brokpan (57,982) Springs (111, 112) Nigel (32,092)—total pop. supplied 1,139,854. Total area 476 sq. mi. Sources of supply and

capac.—Vaal River, 150 m.g.d. when present development project is completed by end of '39 (present capac. 50 m.g.d.); boreholes in Klip River Valley and wells located at 2 pump stations with capac. of 10 m.g.d. Total water sold during yr.—15,175 mil. gal., an increase of 1,334 mil. gal. Av. day—41.577 mil. gal. max.—58.762, min. 31.841. Unaccounted for water reported to be 1.564%. Rainfall for yr. was 35.08", 50 yr. av.—32.76". System contains 422 mi. of pipelines, extending from Vaal River at Vereeniging to the Central Rand—36 mi.; and the 80 mi. from the Witwatersrand from Lebanom on the west, to Nigel on the east. During yr. 60 mi. new mains laid, 24 mi. old mains reclaimed. All water from Vaal River source (88.53% in '38) raised nearly 2000' before being delivered to consumers. Cost of raising 1000 gal. 100' for all stations has dropped from 0.1726d in '32–'33 to 0.1095d for '37–'38, due to installation larger and more efficient pumping units and to increased quantity of water pumped. Water treated with lime and alum; softening incidental at times, hardest water put into system 180 p.p.m., hardness exceeded 140 p.p.m. 21 days, of yr., was between 120-140 p.p.m. 18 days, between 100-120 for 119 days, between 80-100 for 104 days, and for 103 days was less than 80. Will be softened to 85 p.p.m. or less, using lime only. Board's employees number 330 Europeans and 1247 natives. Charts and tabulations given, including financial data.—*Martin E. Flentje.*

Shanghai (China) Waterworks Co., Ltd., Annual Report, 1938. W. P. RIAL. Consumption averaged 46.36 m.g.d., increase of 7.76% over '37. Max. demand was 60.75 m.g.d. Ratio of av. daily to max. daily consumption was 1–1.31 and of hrly. av. to hrly. max. 1:1.67. Unaccounted for water increased from 17.13 to 23.72%, due to wastage from hydrants. Turbidity of Whangpoo R. water was reduced from av. of 103 to 20 p.p.m. prior to filtration with av. dosage of 0.91 g.p.g. alum. All water applied to rapid sand filters was prechlorinated, av. dosage being 1.01 p.p.m. Of total output, 29% was from slow sand plant and 71% from rapid sand plant. Av. rates of filtration were 1.71 and 100 gals. per sq. ft. per hour, respectively. Av. no. of days between cleanings of slow sand filters was 16.56 and water used for washing rapid sand units averaged 2.59%. Larvae of *Diptera Chironomous* again appeared in effluent of some rapid sand filters and their presence was correlated with increased effective size of sand. Reducing effective size by adding fresh sand corrected trouble. In addition to prechlorination, 0.35 p.p.m. Cl was applied to rapid sand filter effluent and 0.24 p.p.m. at main engines. Consumers' complaints regarding water quality numbered 27, 7 of which referred to palatability. Of 1509 samples of water from distr. system examined for coliform bacteria, 95% were negative in 100 cc., 3.8% positive in 100 cc., 0.7% in 10 cc., 0.4% in 1 cc., and 0.1% in 0.1 cc. Cost of pumping per mil gal. was: from river to settling tanks $4.10, from settling tanks to filters $9.15, and from filters to distr. system, $22.28. Details given of efficiency and cost of operating individual units. Cost of steam per 1000 lb. was $1.6653 and B.t.u.'s consumed per lb. of steam produced averaged 1,828. Fuel cost per million B.t.u.'s was $0.73, compared with $0.432 in '37. During yr., 1,346 meters were repaired and reconditioned and 4,331 overhauled, av. cost being $6.27 and $4.31 per meter, respectively. Hydrant maintenance cost was $10.39 per hydrant.—*R. E. Thompson.*

Water Supply and Drainage of the United Provinces. ANON. Surveyor (Br.) **95**: 402 (Mar. 17, '39). Water supply undertakings within the jurisdiction of the Indian Public Health Service supply a pop. of 1.6 million of which only 100,000 are served by privately owned works. The max. consumption of 41 gal. (Imp.) per day per capita occurs at Cawnpore and the min. of 3.1 at Jaunpur. Most filtration plants are in good condition but the distr. systems are out of date. General complaint is too many supervisors and too few competent operators. Many towns in outlying districts are short of water. Cawnpore and Lucknow are embarking on enlargement schemes.—*H. E. Babbitt.*

WATER RATES

Symposium on Sewer Rentals. Sew. Wks. J. **11**: 270 (Mar. '39). Papers before N. Y. Sew. Wks. Assoc. R. C. SWEENEY (N. Y. State Hlth. Dept.): Charges for use of sewers in use since 1894 at Brockton, Mass. Recent survey showed 600 municipalities in 35 states use this method. In '38, Buffalo and Plattsburg, N. Y., adopted Revenue Bond Act (14C, Chap. 525 Laws New York, '35) authorizing bonds and service charges for sewers, sewage treatment works, water supply, bridges, docks, tunnels and self-liquidating and self-supporting undertakings of all kinds. Bonds under this act must be sold to Federal Government, but Act of '29 does not have that limitation. Both acts require that rates must be equitable and unpaid charges become property liens. At Plattsburg, only a few water meters are in use, flat sewer charge ranges from $6.50 for single family and $8 for two-family up to $23 for 17-family residences. Charges collected quarterly as part of single city tax bill. Buffalo Sewer Authority revenue draws 45% from general property tax and balance from sewer-service charge; latter based on amount of water used, if material, at 40¢ per 1,000 cu. ft. up to 9,000 cu. ft. per quarter, 28¢ from 9,000 to 18,000, 16¢ for excess, with minimum charge of 80¢ per quarter. The 16-¢ rate applies to churches, public hospitals, schools and city departments. Single bill for water and sewerage, with separate items. ROBERT A. ALLTON (Columbus, O.): Sewer *charge* preferable to sewer *rental* because users of sewers ask why pay rental for what city owns and is paying for by taxation. In Ohio, most popular basis for sewer charge is water consumption. In making sewer rate schedules should allow for per cent of metered water that does not reach sewers; seems to be about 25%. Where sewage is treated some hold the sewer charge should be based not only on quantity but also strength; importance overstressed and difficulty of determination almost prohibitive. Agreements may be made for abnormal trade wastes. W. F. TEMPEST (Port. Cem. Assoc.): Chicago owners of vacant property should pay ready-to-serve charge. Recent survey of more than 100 communities in various parts of the country showed sewer charge generally based on water consumption. Some communities merely add a fixed percentage to water bill but separate item preferable, even if it is a percentage. State law should provide for making unpaid charges lien on property. Penalty for non-payment effective in many places. M. W. TATLOCK (Dayton, O.): When it was observed that orders to build sewage treatment works issued by Ohio Dept. of Health might be nullified because of lack of funds, the department first refused approval of plans if operating funds were not assured. In '23, it obtained an Act under which any municipality in

Ohio may operate its sewerage department upon a utility basis. Air-conditioning raises problems. This uncontaminated water should not be discharged into sanitary sewers but since it may overtax storm sewers, should not its discharge into them be charged for? Where the sewer charge is based on water consumption, billing and collecting machinery will need only to be expanded to serve both utilities. Dayton, with 48,500 sewer accounts, installed mechanical billing equipment and added only one clerk in its water billing division. (See also abstract J.A.W.W.A. **31**: 402 (Feb. '39)).—*M. N. Baker.*

Missouri Public Service Comm., City of Jefferson et al. v. Capital City Water Company. Commission Rulings. Pub. Util. Fort. (Mar. 30, '39) P. U. R. **27**: 69. Commission instituted proceedings to obtain audit and appraisal of water utility's property to determine its fair value and rate of return. Company sells and distributes water in Jefferson City to 4,100 customers, outstanding stocks, bonds and notes $783,600. Original cost of property not ascertainable. Original construction overheads omitted so Commission fixed 5% for engineering and superintendence, 1% for construction interest. Accrued depreciation allowable on present fair value, not allowable in estimating original cost. Allowance of $759,770.86 for original cost of property and land. Commission cognizant of fact that a utility having business attached and rendering satisfactory service has greater value than identical physical property without these intangibles, consideration given to elements of value but no allowance for going concern. Present fair value, $800,000 including all elements of value, tangible and intangible. Depreciation allowance calculation based on straight line estimates, $11,650 annual on original, 1¼% on subsequent additions, 27½% on subsequent transportation equipment. Operating expenses may properly include prudent expenditures for new business, therefore, expenditure to retain present business in same category. Allowance permitted in operating expenses for loss of customers. A utility is entitled to earn operating expenses, depreciation, and fair and reasonable return on present fair value of property. In fixing rate of return, consideration given to competition, interest rates, security yields, safety of investment, stability of business and to national outlook for prosperity; 6½% return allowed on fair property value of $800,000. Estimated future annual return exceeds this, therefore, rate reduction equal to excess necessary.—*Samuel A. Evans.*

Maine Supreme Judicial Court. Eastport Water Company v. J. W. Raye et al. Pub. Util. Fort. (Jul. 6, '39) P.U.R. **28**: 252. Plaintiff filed action to recover, from certain defendants money due for water service. Before Public Utilities Law became effective company collected for water service on a fixture charge basis with a yearly max.; upon enactment of law company required to file a rate schedule. Company so filed schedule, but without max. charge provisions. Defendants refused to pay over maximum after rate schedule filed. Court ordered: after a schedule of rates is made effective by commission it is unlawful for any public utility to charge or receive a greater or less rate, reinstatement of former max. charge custom impossible, customer defendants required to pay according to published rate schedule.—*Samuel A. Evans.*

Customers Allowed Option to Take Meter Rate Service. ANON. Pub. Util. Fort. **24:** 58 (Jul. 6, '39). Water consumer complained before Penna. Commission against domestic service flat rates. Commission ruled: public utility reserves right to elect that service shall be on a meter rate basis, customer has right to elect meter service, therefore company ordered to give meter rate service if customer so elects.—*Samuel A. Evans.*

Utility Required to Make Studies of Depreciation Rates and to Inventory Property. ANON. Pub. Util. Fort. **24:** 58 (Jul. 6, '39). Utah Commission investigating rates ordered company to make accurate inventory of properties, required for reclassification of property on original cost of construction basis, for new system of accounts. Recently, company made substantial charges for depreciation, without detailed engineering estimates of property lines or depreciation requirements of property, equalling in '38 20% of gross revenues. Commission ruled: detailed engineering studies of depreciable property for depreciation rates required, company should lower rates and modify some practices, resulting in increased consumption of product, time for paying bills before penalty extended to 15 days, penalty reduced to 5%.—*Samuel A. Evans.*

Water Waste Successfully Eliminated in Ontario Municipality. ANON. Can. Engr. **77:** 8: 4 (Aug. 22, '39). Water supply of Owen Sound, 100% gravity system, is derived from 2 sources: Sydenham R., supplying industrial consumers and fire services at 90–110 lb. pressure, and springs, serving domestic consumers at 40–60 lb. pressure. Latter supplemented by river supply if pressure drops below 40 lb. River supply is passed through 2 slow-trickling filters and whole supply is continuously chlorinated, although pollution is infrequent. Consumption is approx. 2 m.g.d. Rates probably lowest in Canada: domestic rates are $6 per yr., and commercial rates, per 1000 gal., based on quarterly meter readings, are 13¢ for first 50,000 gal., 3.2¢ between 50,000 and 1 mil. gal. and 1.1¢ for amounts in excess of 1 mil. gal. With view to eliminating waste, telemeter system was installed at chlorination station to measure flow and transmit readings to superintendent's office 1.5 mi. distant. Recording and transmitting equipment is described briefly.—*R. E. Thompson.*

The Social Idea Underlying Water Rates. HENNING BARTELS. Gas.-u. Wasserfach **82:** 630 (Sep. 2, '39). It was found that standardization of water rates for industrial users is impossible, but can be done for domestic users. The minimum rate should depend on the number of rooms in a residence. In this way social conditions are considered without direct relation to variables like the amount of water used, the number of sanitary installations available or the size of the family. Public authorities should not get cheaper rates than those of corresponding wholesale consumers, as a water supply should be operated on a commercial economic basis. The water should be sold only metered and not by lump sum. The use of water is an important indicator of cultural development, which grows with the increase in the facilities for its use. Lump sum rates based on types of installations in use do not reduce the amount of water consumed, but restrict the installation of facilities needed to a modern civilization.—*Max Suter.*

DISTRIBUTION MAINS

Factors Affecting the Cost of Distributing Systems. WILLIAM W. BRUSH. J.N.E.W.W.A. **53:** 278 (Sep. '39). Mains, valves and hydrants constitute 80% or more of the original or investment cost of the distribution system. This cost substantially affected by number of causes, some subject to control, others not. When these items considered together with pop., its density, mfg. and business establishments, their location and water requirements, not difficult to understand variation in costs from system to system. Comparisons made for '30 costs of mains in 3 cities—(1) Chicago, (2) Hartford, Conn. and (3) Louisville, Ky.—for 6" pipe these being respectively—(1) on unimproved streets—$1.45 per ft. of main.—improved streets—$9.08; (2) for material—$0.85, total $1.70; (3) 74% of Hartford costs. Costs of maintenance and operation also discussed.—*Martin E. Flentje.*

Training Employees to Make Good Joints in Water Mains. W. M. RAPP. W. W. Eng. **92:** 1312 (Oct. 11, '39). Description and illustration given of Atlanta, Ga., shop device to allow making of practice joints in a split sleeve, including yarning, pouring and caulking. Found useful in that it provides water dep't. with several reserve trained men.—*Martin E. Flentje.*

Asbestos-Cement Water Pipe to be Coated (in New Hampshire). ANON. Health News, N. H. State Board of Health **17:** No. 8 (Aug. '39). Because of tendency of soft N. H. water supplies to act upon asbestos-cement pipe in some degree for at least a rather substantial time following installation, it has been deemed advisable to require provision of a durable coating. In new water systems interior of such pipe must be thoroughly coated with bitumastic or similar inside coating.—*Martin E. Flentje.*

New Types of Couplings for Distribution Piping, Tappings and Valves. M. E. BERRIAT. Tech. Sanit. Munic. (Fr.) **34:** 81 (Jun. '39). Illustrated discussion of couplings with rubber gaskets for use on plain end pipes. The "Travil" is the original design. These couplings are widely used. Their essential characteristic is the compression of the packing rings, whether it be in the sockets of the pipes or in movable rings on smooth pipes. Their lack of resistance to pulling apart of the pipes is a fault. The "Gibault" coupling is similar to the "Travil." The "Precis" when it appeared was an improvement. It reduced the squeezing out of the rubber gasket by more exact fitting of the parts, thus permitting greater pressures. The "Standard" joint, in '27, reduced the relative loss of packing material through the clearance openings by doubling the section of the elastic ring. In joints of this type too great extrusion of the gasket through clearance spaces will destroy its elastic reaction through excessive deformation. The life of rubber is reduced by such conditions. This problem is met in part by fabric reinforcement of the rubber to prevent plastic discharge, but such reinforcement also interferes with desirable elastic properties. A metallic shield, of lead in some cases, is used to protect the rubber from extrusion, and the pointed form used by the Ameri-

can "Dresser" coupling has good features. The "Precis Express," a French improvement using bell and spigot pipe, has a reinforced rubber gasket and a lead shield. The bolting is of a special design limiting the pressure on the gasket. The "Metastandard" joint is a design used to introduce an occasional flexible joint into a welded steel piping system where the welded joints are made up by first slipping an enlarged end of one pipe over the end of the next pipe. The "Metastandard" joint takes the place of a weld by coupling such pipe with no change in the pipe ends or special fittings. A type of tapping collar or clamp is described for use in connecting smaller branch pipes or service connections to mains. This collar, known as the "Secur," includes a gasket which is completely enclosed to prevent its squeezing out under pressure. With it taps may be made, under pressure or not, into a main pipe of any material. A "Secur" coupling is also described which is similar to the "Gibault" but which has a gasket of much larger section. Adherence to the pipe is increased such that the pull out resistance is much increased. A coupling known as the "Perflex" is a type used to connect valves into pipe lines. It allows flexure of the line and also allows removing the valve without disturbing the pipe on either side. This coupling, when provided with certain parts of Bakelite, becomes an electrically insulated coupling and is then known as the "Isoflex."—*Willem Rudolfs.*

Laying Lined and Wrapped Steel Pipe at Needham, Mass. ROGER G. OAKMAN. J.N.E.W.W.A. **53:** 271 (Sep. '39). Description given of laying of 3400′ steel pipe line on main line from new pumping station at Charles River. Steel pipe used, 14″ o.d., random 40′ lengths, slightly less than $\frac{1}{2}$″ thick, weighing 30.92 lbs. per ft., lap welded and designed to carry working pressures up to 375 lbs. per sq. in. Lined with bitumastic lining; exterior protected by combination asphalt-base enamel with saturated rag felt PRX—1 wrapping. Job started Jul. 5, completed Oct. 10, '38, cost approx. $15,000.—*Martin E. Flentje.*

Water Main Construction Methods in New Westminster, B. C. ANON. Eng. Cont. Rec. **52:** 29: 16 (Jul. 19, '39). Wrapped steel pipe and patent couplings, adopted for 8″ main 1700′ long, is believed to be answer to problem of laying mains in muskeg and other shifting soils along waterfront in New Westminster. C.i. pipe with lead joints develops leaks in this soil, and steel, as ordinarily used, corrodes. To prevent corrosion, pipe is coated with asphaltum, double wrapped with jute and finally coated again with asphaltum. Coupling is similarly wrapped and coated in place. Pipe has greater tensile strength than c.i. and cost of pipe is about same. As installation is simpler, there is small saving in completed cost. Steel is $\frac{1}{4}$″ thick.—*R. E. Thompson.*

The Use of Lined and Wrapped Steel Pipe in the Augusta Water District. SIDNEY S. ANTHONY. J.N.E.W.W.A. **53:** 274 (Sep. '39). 4000′ of 8″ steel pipe with valves and hydrants laid to supply portion of district outside Augusta, Me. Pipe used—$8\frac{5}{8}$″ o.d., lined with coal-tar bitumen, wrapped on outside, random in length varying from 36′ to 45′. Services located to center of every 3rd lot with branches to each. Total cost $12,285.—*Martin E. Flentje.*

RECONDITIONING WATER MAINS

Cleaning and Lining Existing Pipe Lines in Buenos Aires. BRUCE HARKNESS. J.N.E.W.W.A. **53:** 284 (Sep. '39). Water for Buenos Aires taken from the Rio de la Plata, is very soft and corrosive. Found pipe in service for 10 yrs. or more, markedly corroded. Description given of cleaning and lining 5″ i.d. mains laid approx. 23 yrs. before which had become filled with tuberculated matter to about 3″ diam. Mains first cleaned with 2 Tate cutter-type cleaners in tandem, winch drawn, travelling at 5′ to 45′ per min. and capable of cleaning up to 1000′ per 8 hr. day. Amt. of corrosion extracted averaged approx. 12 tons per mi. Lining decided upon—½′, reducing effective diam. of pipe to slightly less than 4½″. Mixture 2 parts sand to 1 of portland cement used, water added to obtain slump of approx. 9″ (varies for each pipe size, 9″ for 5″ pipe, 4½″ for 10″). All of mortar fed into main first, filled 80′ of 432′ to be lined, then spread by liner of patented design, compacts mortar on to wall of pipe at pressure of approx. 130 lb. per sq. in., lining when completed homogeneous and continuous. 266′ of main (5″) scraped, plunged and dried preparatory to lining in 1 hr. 50 min., 7 min. taken to load mortar into pipe, and actual time to line pipe 12 min. Flow test before cleaning was 97 g.p.m., after cleaning before lining—287 g.p.m., and after lining—261 g.p.m. W. & H. flow coefficient on actual diam. within lining, on 5″ pipe in England found to be 157. Complete cost for cleaning and lining, including excavation, pipe work, installing auxilliary service, reconnecting, resurfacing, depreciation and all overhead charges worked out to ¼ of the cost of complete renewal. *Discussion.* THOS. H. WIGGIN: Observations in Manchester, Eng. in '34 indicated Tate process regularly used in dist. pipe 3″, 4″, 5″ in diam., with work done at a profit for a small fraction of the cost of new pipe lines. W. & H. flow coefficients on 3″, 4″, 5″ and another stretch of 5″ pipe were respectively 63, 88, 97 and 97 as calculated on nominal diam. of pipe and 148, 152, 142 and 157 when calculated on actual diam. within lining, relatively low for small pipe and higher as size increases.—*Martin E. Flentje.*

Reconditioning of Tod River Trunk Main. L. R. STEELE. J. Inst. Engrs. Australia **11:** 209 (Jun. '39). About 3000 sq. mi. in Eyre's peninsula, South Australia, are served by the Tod River reservoir, of 2318-mil. gal. capac., water from which is pumped to the 950,000 gal. Knott's Hill tanks and from them gravitates through the system. Trunk main extends 240 mi. and varies in diameter from 21″ to 10″, there being several other tanks along the line. First section, 128 mi. long, laid in '25 and terminated at Minnipa, where a 5-mil. gal. tank has been constructed. Both internal and external corrosion, after only a few years service, proved to be very severe. Internal corrosion arrested by installation of de-aëration in '32. External corrosion largely due to salty nature of soil. Already in '33, bursts had become so frequent that it was evident that most of the main as far as Minnipa would have either to be reconditioned or replaced. The first 39 mi. being the worst, a beginning has been made on this section. Original main, of 20″, single lock-bar steel pipe, in 28′ lengths, and joined by mild steel collars packed with lead, with stop-valves at approx. every mile, was laid underground. Reconditioned main being laid

above ground and is of rigid construction, all joints being welded, and all thrusts at changes either of grade or of alignment, and at stop-valves, being taken by specially designed thrust blocks of reinf. concrete. First mile replaced by new 21″ welded cement-lined pipe, which, for lack of space, had to be laid in old trench. Old pipes from this mile were carried forward to second mile, reconditioned in the field, and relaid above ground. In similar manner each mile in turn is being taken up, carried forward, reconditioned, and put back into use, delivery into old main being effected through flexible by-pass, which is itself moved forward, a mile at a time, as needed. Standardized procedure is, briefly, as follows:—(1) set out line of new main and construct stop-valve anchors for 2 mi. ahead; (2) open up trench, remove joint rings, salvage old lead, lift pipes out; (3) carry pipes forward into position for next mile, clean them thoroughly, inspect for defects, make good all defects, line pipes with cement; (4) assemble the reconditioned 28′ lengths three together to 84′ lengths by butt-welding with Linde machine; (5) wedge up these long lengths into their final position and weld together to form main, leaving open temporarily one joint every 700 or 800 feet; (6) thrust-blocks are brought nearly to completion, pipe movements due to temperature change being left unimpeded; (7) final adjustments are completed, the last being to link in the joints left open at as near mean temperature as possible, sleeves being welded on over them; section is charged and examined for leaks; (8) by-pass is shifted forward and section put into use; (9) concreting of thrust-blocks is completed; (10) outside of completed main is scraped free from rust and painted. Line of new main parallels that of old, with 6′ interval between. Levels taken about every 25′, but closer when necessary. Stop-valves located preferably at summit levels. Grade changes kept as few and as small as possible. Bottom of pipe kept at from 6″ to 12″ from ground. Distance between thrust-blocks does not exceed 9 pipe-lengths, even when no change of grade occurs. In reconditioning of old pipe, ends under lead joints are generally corroded and have to be cut off; internal pitting, which is considerable, is made good by electric welding; external damage is made good by welding on patches with portable arc-welding plant. Lining with cement was troublesome; a 1:2 mix was shovelled into pipe and a "torpedo" device drawn through after it by means of a horse. The shell of the torpedo is maintained by runners and springs at ½″ distance from wall of pipe and compacts the concrete tightly. As only about 120° of pipe's circumference can be covered at one operation, three operations are necessary. A short length at each end of pipe is left uncovered until after the weld, when it is finished by hand with cement mortar. Where pipe could be rotated, welding done with the Linde machine, such welds being stronger by test and at same time cheaper, than best hand welds. Stop-valve anchors (illustrated) are designed to withstand thrusts due to (1) water pressure of 200 pounds and (2) temperature changes. Maximum thrust of 90 tons occurs whenever, with main empty, temperature attains its maximum of 125° F., or 60° above the mean. Thrust-block plans, designed for same conditions, also given. Two concrete chairs (illustrated) support each pipe at 14′ intervals. Malthoid sheeting is interposed between pipe and chair. Precautions observed in adjustment of by-pass are detailed. For external painting, experience has proved that 2 coats of red lead, with surface coat of aluminum paint, will be satisfactory.—*Frank Hannan.*

The Reconditioning of a Pipe Line. ANON. Wtr. and Wtr. Eng. (Br.) **41:** 499 (Oct. '39). *From a paper by* B. L. HAMILTON *before New Zealand Inst. of Engineers.* The Waitakere pipe line, consisting of 7½ mi. of 24″ c.i. pipe and 6 mi. of 27″ c.i. pipe was laid by contract in '06. Because of troubles from leaking joints, loose valves, and corrosion it was decided to exhume, recondition, and relay the line at an estimated cost of £65,000, against an estimated cost of £110,000 for a new main. Unexpected difficulties encountered in excavation due to slipping ground, effects of old leaks, and old excavations improperly backfilled. Trench timbering was troublesome, as was water in the trench. Reconditioning consisted in scrapping the collar on the old lock-bar joint, welding new sockets on the pipe, approximating the sizes of British standards. Clay was placed in the joints from the inside of the pipe and after the joints were run with lead the clay was removed. In some places the pipe was relaid with a 6″ sheathing of a special mix of bituminous hot mix macadam composed of ½″ blue metal chips and a 60:40 bitumen-tar compound to avoid electrolysis. Part of the excavation was done in tunnel. On the whole the pipes were in fairly good condition and in only one portion was there found to be any extensive signs of internal corrosion. After the pipes had been removed from the trench they were cleaned, in some cases patches were applied, the new socket was welded on, they were tested up to 250 lb. per sq. in., preheated to 300° F., dipped in a bath at 330°, coated with hessian while revolving in the bath, lifted out, drained, and rolled in sand. They were then replaced in the trench.—*H. E. Babbitt.*

VALVES AND HYDRANTS

Valve Operation and Maintenance. THOMAS M. LATIMER. Md.-Del. W. and Sew. Ass'n. **13:** 34 ('39). Main points in operation and maintenance of valves are: systematic operation, standard method of operation and standard type valves. Closing and opening each valve at least once each yr. will lower cost of repair and replacement. Water Div. of Washington, D. C. has adopted standard method of opening valves which each workman is required to follow. Divide-valves on large mains should be located at low points or on grades, never on top of hill, elevated location makes getting rid of air difficult if main charged through high valve.—*Martin E. Flentje.*

Tuning Up Pressure Regulators. D. D. GROSS. Eng. News-Rec. **123:** 466 (Oct. 12, '39). Experiences in Denver with pressure regulating valves are outlined. When Moffat tunnel was placed in service, conduits between mountain reservoirs and distr. system were provided with regulating valves of various types. Selection of proper size is important. If failure of valve would deprive considerable portion of system of water, 2 valves, one smaller than other to take lower flows, should be provided. Similarly, where closure seriously interferes with service, dual valves should be installed, with means of closing off each to permit inspection and repair. In Denver, valves are inspected and tested weekly. In each vault is located a 2-pen recording pressure gage connected to piping on either side of valve. Seven-day charts are used and are changed at time of weekly inspection. Regulating valves are usually equipped with small pressure-reducing valves to reduce pressure on

high-pressure side of regulating valve to some fixed value which can be applied to one side of diaphragm which sets in motion the automatic operating mechanism. With uniform pressure on upstream side, diaphragm will move in response to pressure on downstream side. Variations in upstream pressure, however, at times hinder uniform operation of small valves and results in "hunting". Pneumatic tanks have been found more satisfactory in Denver for controlling upstream pressure on diaphragms. Modern types of regulating valves will control pressure to within 2 lb.—*R. E. Thompson.*

Maintenance of Hydrants. W. V. Weir. W. W. Eng. **92:** 1120 (Aug. 30, '39). Desirable to inspect all fire hydrants a short time before freezing weather in fall and author lists 7 items such inspection should embrace. Distribution system should be flushed in spring and hydrants checked, repaired, painted and flow checked. *Ibid.* p. 1122. Stephen H. Taylor. Hydrants checked both fall and spring at New Bedford, Mass. Flushing and testing crew consists of 6 men, hydrants painted with good grade paint every 3–4 yrs. Annual cost of semi-annual flushing and inspection between $2,000 and $3,000.—*Martin E. Flentje.*

DISTRIBUTION STORAGE TANKS

Water Storage in a Spheroidal Tank. Anon. Eng. News-Rec. **123:** 291 (Aug. 31, '39); *see also* W. W. and Sew. **86:** 347 (Sep. '39). Requirement of providing 1 mil. gal. storage within head range of 30′ in structure of esthetic merit in high-value residential district of Brookline, Mass., was met by construction of spheroidal-shaped tank 90′ diam. at widest point (equator) and 47′ high above ground surface. Copper-bearing steel plates and structural members were electrically butt-welded. Capacity of tank is 1.65 mil. gal., of which 1 mil. gal. is available within head range of 25′. Shape approximates that assumed by rubber balloon filled with water and resting on flat surface. Economy results from elimination of practically all metal used in other types of structures for maintaining form. Plate thickness varies from $\frac{1}{4}$″ to $\frac{13}{32}$″. Recently developed phosphoric acid pickling process for removing mill scale was employed, consisting of immersion in warm sulfuric acid solution, washing twice with warm water and dipping in warm phosphoric acid to which small amount of iron has been added. This leaves thin coating of iron which acts as rust inhibitor and improves bond with paint, applied while plate is still warm. Tank was surrounded with huge evergreen trees (some over 35′ high). Color and gloss of special gray paint employed, plus rounded shape, makes tank blend with sky where it shows above trees. Total cost was $92,750, of which $37,850 was for tank, $20,000 for foundation and gage house and $12,800 for landscaping and grading.—*R. E. Thompson.*

The Inside Story of the Elevated Water Tanks for the Indianapolis Water Co. William C. Mabee. W. W. Eng. **92:** 1302 (Oct. 11, '39); *see also* W. W. and Sew. **86:** 431 (Nov. '39). 1½ mil. gal. elevated steel "Blue Ridge Tank" supplying part of 395,000 inhabitants of company's territory, completes demonstration of elevated tank usefulness to this Co. and reflects changes in art of elevated tank construction. Found that demand rates in the district served by

tank for max. day may equal or exceed 300 gal. per capita during max. hr. whereas av. use for max. day may not exceed 135 gal., with yearly av. days consumption in district only 53 gal. per person. Tank is 96′ high with 30′ depth of water, is spheroidal in shape with radial-cone bottom supported on 16–54″ cylindrical steel columns, 12 outer columns being equally spaced on a 74′ diam. circle. Parts joined by electric arc welding. Control chamber located underground directly under tank. Metal protected from corrosion by cathodic protection device; no paint applied inside below water line.—*Martin E. Flentje.*

Water Tower-Town Hall Completed at Lake, Wis. ANON. Eng. News-Rec. **123:** 508 (Oct. 19, '39). Town of Lake required water tower and town hall and it was decided to combine the two. Million-gal. water storage is provided in 65′ diam. steel tank, top of which is 162′ above ground. Octagonal concrete shell encloses steel frame and lower half of tank. At ground level, built integrally with tank and surrounding it, is one-story structure which houses softening plant, municipal offices, etc. Town hall, seating 300, occupies second floor. As more space is needed, upper floors can be built. Space has been provided for elevator shaft. Offices are air-conditioned, using water from town well, 1860′ deep and supplying 1000 g.p.m., at 65°F. Cost was $1,325,000. The 20-acre site of structure is municipal park.—*R. E. Thompson.*

Reservoir Remote Signal Cuts Operating Costs. G. E. WRIGHT. W. W. Eng. **92:** 1044 (Aug. 16, '39). Original device made by author costing $30 has proven successful and has reduced power bill $300 per mo. because with it, pump station operators need not overflow reservoir to insure its being full. Ingenious arrangement of float, guide rod with stops and actuating rods attached to pulleys provide for opening and closing electric signalling circuit without cold weather interruptions or stuttering of light signals. Illustrations given.—*Martin E. Flentje.*

PUMPING AND POWER

Perfection in Automatic Pumping. LEON SMALL. Eng. News-Rec. **122:** 779 (Jun. 8, '39). Recently completed Pleasant Hill Pumping station in Baltimore is described. Station, which is entirely automatic, embodies features developed in 25 yrs.' experimentation with automatic control equipment. Station is underground, thus eliminating heating facilities and reducing operating noise. This introduces problems of drainage and waterproofing, but operation and maintenance cost advantages overbalance high construction costs. Condensation eliminated by dehumidifying equipment. Pump installation consists of two 1000-g.p.m. single-stage centrifugal pumps delivering against net head of 127′ and driven at 1765 r.p.m. by 40-hp. squirrel-cage motors. By telephone supervisory system, information concerning electrical and hydraulic conditions may be obtained at any time by call to station from any point on telephone system, equipment responding in buzzer code with all necessary data.—*R. E. Thompson.*

Selection of Pump Units for Water Works Controlled by Compressed Air. FRANZ LEINER. Gas-u. Wasserfach **82:** 138 (Feb. 25, '39). Size of pumps in manually operated plants is selected to give best adaptability to the plant requirements. For plants automatically controlled by compressed air it is better to select all units of the same size. Reasons are: (1) Larger pumps and motors have better efficiency, small pumps working for long periods should therefore be avoided. Large pumps require a large current for starting, but they do not necessarily start oftener, as the starting period depends on the time of emptying the tank. (2) Automatic plants should not have to pay a standby fee. Thus the kind of units would be of no importance. (3) Cost of pumps and motor is somewhat less if units are of equal size. (4) Construction cost is also less. (5) Every motor can be used for any pump. (6) Equal wear of all mechanical and electrical parts is obtained. (7) The least stock of reserve parts is required. (8) As the size of the compressed air tank depends on the largest pump used, it will be the smallest if all pumps are of equal size.—*Max Suter.*

American Centrifugal Pump Design. ANON. The Engr. (Br.) **167:** 590 (May 12, '39). For deep-well turbine pumps the tendency is to use water lubrication; rubber bearings and non-corrosive sleeves at shaft bearings are improvements in detail. In ordinary types of pumps there has been some increase in guaranteed efficiency and pressure. Centrifugal pumps driven by steam turbines are increasing, although for some years the trend has been toward electrically operated units. There is increasing use of combination units in which a steam turbine drives through speed-reducing gearing a pump of relatively high head and horse power, and also an electric generator, all mounted on the main floor. A second pump of the same capacity as the first, but of much lower head, is driven by an electric motor taking current from the generator, which may also supply current for auxiliaries.—*H. E. Babbitt.*

Experiences in the Use of a Thrust Bearing of Artificial Material in a Centrifugal Pump. ALRED GROSSMANN. Gas-u. Wasserfach **82:** 567 (Aug. 5, '39). A horizontal centrifugal pump of 550 g.p.m. capacity against 334′ head at 1465 r.p.m. had originally in its thrust bearing a moving steel ring and a fixed bronze ring. After every 100 days of operation the steel ring had penetrated 4 mm. deep into the bronze ring and both rings had to be replaced. The fixed ring was replaced by a ring of artificial resin (Dytron, quality Tex) and the moving steel ring received 6 radial grooves for lubrication with water. This required replacement after 10 days. The same lack of success was had by replacing the steel ring by a bronze ring with six grooves or by using the steel ring in the fixed position with the resin ring rotating. However wear was reduced to such an extent that the rings had to be replaced only every 1250 days by using a fixed smooth bronze ring and having radial and also lengthwise grooves in a rotating resin ring.—*Max Suter.*

The Aerodynamic Testing of Centrifugal Pumps and Water Turbines. ANON. Engineering (Br.) **147:** 93 (Jan. 27, '39). In spite of the apparent unreasonableness of the use of a compressible gas such as air, in testing of centrifugal

pumps it has been shown that compressibility of medium is of small importance in considering the physical aspects of its flow, provided the changes in temperature and pressure are small, and the velocity of flow of the air is low compared with the velocity of sound. The close hydrodynamic similarity between the design of centrifugal pumps for moving water and of fans for moving air has made possible a technique whereby pumps may be tested with air. This possibility offers many practical advantages over tests with water. The testing of model runners with air can be extended to ascertaining the important quantities in magnitude and direction of the inlet and outlet velocities by means of calibrated Pitot tubes and by stroboscopic methods, which give more accurate results than is possible by hydraulic research.—*H. E. Babbitt.*

A New Reciprocating Pump. ANON. Wtr. and Wtr. Eng. (Br.) **41**: 263 (May '39). The pump has two cylinders, horizontally opposed. A substantial rubber ring, normally compressed until it is oval, provides the seal and obviates the need for glands. There is no frictional contact as movement of the piston only imparts an easy rolling motion to the sealing ring. The valves are flat seated and of reinforced rubber. An important advantage of the pump is its ability to deal with liquids containing suspended matter. An experimental pump operated by a ¼-h.p. motor has capac. of 500 g.p. hour (Imp.) against a head of 25′ with suction lift of 14′. The pump is self-priming and does not require a foot valve.—*H. E. Babbitt.*

A Guide to Gas Engine Maintenance. L. S. KRAUS. Munic. San. **10**: 480 (Oct. '39). The importance of proper gas engine maintenance is illustrated by a discussion of the costs of emergency and standby power in case of failure of gas engine driven generators in a sewage treatment plant. The article is based on experience with two gas engines in the Peoria, Ill., plant. The author gives, item by item, a description of the maintenance needed, the frequency of the need, and the methods of maintenance for all wearing parts and all auxiliaries of gas engines. ★[The article is in fact a maintenance manual for the particular type of engine and can not be briefed without omitting important items.]★ Records of maintenance are of great value in developing proper maintenance schedules.—*Homer Rupard.*

Cooling-Tower Fundamentals and Their Application to Cooling Diesel and Gas Engines. GUSTAVE J. BISCHOF. Trans. A. S. M. E. **61**: 1: 25 (Jan. '39). Size and cost of a cooling tower varies with certain conditions, some of which are inherent in the design, others are influenced by location and type of service, and still others may be fixed by the purchaser. In the last groups are proper relation of water circulated and range of cooling for a given heat dissipation, the location of the cooling range in the temperature scale, and the relative size of the cooling tower compared to heat exchanger when both are operated as a unit. Purchaser often unaware that reasonable modification of these factors may considerably reduce size and cost of the cooling system. Narrow cooling ranges with relatively high water circulations are conducive to optimum heat transfer, both from standpoint of high temperature differences and high heat transfer coefficients in the heat exchanger. Choice of kind of engine-cooling

system depends on many factors besides first cost, such as space requirements, operating cost, and trouble-free operation. Use of closed systems, while relatively high in first cost is often justified on basis of yearly operating charges and low maintenance cost.—*Homer Rupard.*

Oil versus Coal in Water Works Operation. W. F. SCHAPHORST. W. W. and Sew. **86:** 314 (Aug. '39). Nomograph for facilitating economic choice between coal and oil, accompanied by brief information on other considerations. —*H. E. Hudson, Jr.*

The Welding of Boiler Drums and Shells. S. F. DOREY. Trans. Liverpool Eng. Soc. (Br.) **60:** 140 ('39). The author presents a resumé of the art of welding boiler drums and shells in England and the U. S. The process of forge welding drums as practiced in England and on the Continent is reviewed. ★[This process is obsolete in view of the present state of the art in the U. S.]★ The extent of fusion (electric-arc) welding in the U. S. is described briefly. Fusion welding allows use of thicker shells, eliminates caustic cracking at seams, gives more uniform stress distribution and reduces total weight. Fusion welding has not been readily accepted in England for various reasons. Materials for fusion welding may be ordinary low carbon steel. Higher strength and quality steel reduce weight, but require particular attention to welding technique. Shielded electrodes are essential in high quality welding. The composition of the welding rod should result in deposited weld metal that matches the parent metal. The type of joint influences the electrode size. Weld metal is deposited in successive layers with each layer chipped and peened before depositing the subsequent layer. The "Unionmelt" process allows the deposition of thick weld in one layer. Edges for welding are prepared by planing. Space between the edges is important. Backing strips usually used. Automatic welding permits faster and more uniform work. Special care in shaping, lining up and fitting of parts to be welded increases as the quality and weight of the work increases. Photographs of various phases of work (all from U. S. plants) are shown. X-ray examination is used for all high class work. This detects porosity, lack of penetration and cracks. The details of the detection of each of these types of faults is discussed. X-ray pictures are shown of the various defects. Thermal stress relieving is used to remove shrinkage stresses about the weld. Usual practice is to heat to 600-650° C. for one hour per inch of metal thickness, cool to 300° in the furnace and then to atmosphere in still air. About 90% of residual stresses are relieved this way. Large furnaces are built to take entire vessels for this process. Test plates are attached to the ends of the drum to be welded, then cut off and subjected to various tests to determine the soundness of the weld. The Magnaflux test is used in addition to others by the Babcock and Wilcox Co. Author concludes that by a careful inspection and test procedure that a safe and reliable welded structure will be assured. ★[The art and knowledge of fusion welding in England is 10 to 15 years behind practice in the U. S.]★—*Homer Rupard.*

The 1939 Convention

THE fifty-ninth convention of the American Water Works Association was held in Atlantic City, New Jersey, June 11 to 15, 1939. The Ambassador and Chelsea Hotels were official co-headquarters. The exhibits and technical sessions were held in the Atlantic City Auditorium.

The registration of 1290 was the largest ever recorded at an A. W. W. A. convention. The registered attendance total at the past ten conventions was as follows:

Year	*City*	*Total*	*Year*	*City*	*Total*
1930	St. Louis	1021	1935	Cincinnati	901
1931	Pittsburgh	1076	1936	Los Angeles	891
1932	Memphis	712	1937	Buffalo	1140
1933	Chicago	660	1938	New Orleans	1123
1934	New York	891	1939	Atlantic City	1290

An innovation in committee organization was most successful. Instead of organizing committees with the convention city as a basis, the New Jersey Section was called upon to serve. J. Arthur Carr, chairman of the Section, was chairman of the General Host Committee. The hospitality at each entertainment event was promoted by a New Jersey committee.

The various events and their special chairmen were:

Water Works Get-Together	Chrystal Brown
President's Reception and Dance	S. F. Newkirk, Jr.
Ladies' Boardwalk Tour	Mrs. William G. Banks
All Section Dinner	H. N. Lendall
Monte Carlo	W. C. Flanders and H. P. Croft
Ladies' Luncheon Bridge	Mrs. D. B. Stokes
Dinner Dance	J. Arthur Carr

William J. Orchard was Convention Management Chairman. Clinton Inglee was in charge of entertainment, with Mrs. W. J. Orchard in charge of ladies' entertainment. Lincoln Van Gilder was local host for the convention and graciously provided transportation for all those persons who wished to travel about Atlantic City.

President Reeves Newsom addressed the convention at its opening session. He said in part:

"During the past thirteen months the American Water Works Association has continued its phenomenal growth in number of members and in the interest of the membership in its activities.

"With the exception of two, all Sections have more members than a year ago. At almost every Section meeting I have attended in that period, all former records of attendance were broken. There was displayed everywhere the greatest of enthusiasm in the work of the Association and the number present at the technical sessions was, with few exceptions, all that reasonably could be expected. As the year has progressed, I have noted an improvement in the general balance of the programs of papers to be presented and the culmination of that phase of our progress is represented in the program arranged for this convention. It has, I believe, so much of interest, so much that is useful and instructive that it is a further conclusive reason why water works men everywhere cannot afford to be without membership in this Association.

"The past year has witnessed the dividing of the Central States Section into four very active Sections. It was my privilege to be present at the last meeting of the old group when the remaining portion organized as the Western Pennsylvania Section, and to attend the first regular meetings of the Michigan, West Virginia and Ohio Sections. They all give great promise of materially strengthening the Association in their respective states.

"Good progress has been made this year in the speeding up of important committee work. In connection with the revision of certain of the basic specifications, a basis of cooperation has been arrived at with the New England Water Works Association so that, when completed, they will be jointly sponsored by both associations and duplication of effort will have been avoided. Such an arrangement already in effect as to cast iron pipe, has been extended during the past year to include the revised gate valve, hydrant and meter specifications.

"I have brought to the attention of the membership at large who were in attendance at Section meetings, the scope and importance of our committee work. I have found a surprising ignorance on the part of many members of what is being done for them by men serving on the Association committees. On the other hand, I found a tremendous interest on the part of our general membership in hearing

the story of what the committees were doing. I am hopeful that, to some extent at least, there will be a greater readiness both to serve on and to cooperate with committees on the part of the individual members as they become more cognizant of what is going on. I believe a continued effort to keep them informed is well worth while.

"The water works industry should gird itself against the aftermath of P.W.A. Additional funds may or may not be provided for further work under federal auspices. The amounts will, in any event, probably be smaller than those available in the past few years. So accustomed have city administrations become to doing work of the type of water works extensions only when federal funds are contributed that a distinct psychological problem has arisen. Improvements and extensions to water systems have become classed with all other make-work projects because so much has been carried on under P.W.A. The work that has been done is certainly in every way highly acceptable. Facilities have been extended to many communities and in many existing systems to an extent not otherwise possible for a number of years in the future. There remains, however, the problem of extracting water works from that class of work which is done primarily to relieve unemployment and of re-establishing it in the minds of administrative and legislative bodies as something which will always at frequent intervals need to be done because of the vital character of the service."

The convention was honored by the presence of Governor A. Harry Moore, of New Jersey. Parts of his address, given on June 13th, follow:

"The State of New Jersey is signally honored to entertain the American Water Works Association at its fifty-ninth annual convention, the more so because this is the first time your annual convention has ever been held in the State of New Jersey. Your Association is an old and honored institution and has done much during its existence to promote a fine spirit of public service among the water works operators generally throughout the country. It is a significant fact that the operation of the water works of American municipalities is the one branch of public service wherein politics has played a minor part. As a rule the men employed in the municipal water works throughout the country have been the least disturbed by political turnovers and have taken the least part in political activities. It seems to be a field of municipal endeavor where the officials of both parties keep hands off and permit the scientific man operating the

water plants to operate them without let or hindrance. I believe this condition has been brought about in a large measure through the activities of this organization. Your splendid organization has created a morale among water works men that places public service on a high plane.

"There is probably no field in municipal endeavor which has so directly affected the health, comfort and happiness of the American people as has been done by the supply of pure and wholesome water. Just a little more than thirty years ago, Jersey City was struggling with serious pollution on its watershed from which it derived its potable water supplies, and was involved in considerable litigation looking to the abatement of the pollution. The typhoid death rate in Jersey City had at times been as high as 100 per 100,000. Other cities in New Jersey and in the United States had a like experience. Some of the distinguished members of your Association in those early years established at the Boonton Reservoir, the source of Jersey City's water supply, the first apparatus for the chlorination of water. The entire supply of Jersey City's water, then about 40 million gallons per day, was disinfected with hypochlorite of lime. This was the first plant in North America, if not in the entire world, of its kind. Within a few years after this plant was put in operation typhoid fever in Jersey City was eradicated and today there is hardly a death per year from typhoid fever in the entire city. Hundreds of cities throughout the United States since then have followed the example of Jersey City in the establishment of chlorination plants, and as a result typhoid fever is no longer considered a major factor in the administration of public health. This result was largely achieved through the cooperation of the authorities and the men of the American Water Works Association, and I am proud of the part that my City and my State took a generation ago in pointing out the way for this great service to public health."

President Jensen, in taking over the Presidency of the Association on Thursday, June 15th, said in part:

"This Association is definitely making progress. The knowledge of the industry is continually advancing. Operating activities are becoming more and more extended. The policy is to make this knowledge and experience available and valuable to all members for use in the water works field.

"There is a steady increase in membership and a significant interest in all the transactions. Advancement is made possible

through the set-up of activities covering all branches of water works endeavors and needs, guided by the Practice Committee. Each subject is a matter of special study and final conclusions are reached only after painstaking efforts. Proceedings and papers are carefully edited and a large array of water supply literature is made available for reference and the guidance of the membership.

"In all this, the Association has made itself of inestimable value to the industry and as advancement is made in knowledge and experience, these facilities will become more and more indispensable to progressive operators.

"Water service is one of the most important of all public utilities. As operators improve in qualifications, so should they have the distinction of being the outstanding citizens of the community in which they are engaged. As such, they will be enabled to retain the confidence of the public and by this friendly relationship to render more efficient service.

"The contacts made *here* are very important, but it is in the Section meetings that *most contacts* are made. At the New Orleans convention, out of a membership of 3300 there were 488 present—15 per cent. The total registration was 1123. Last year in 21 Sections having a membership of 2911, there were present in meetings 1348 members, or 46 per cent. The total Section registrations were 4355. Most of the Sections had excellent programs. Local problems dominated the meetings. Directed discussions were very popular in many instances. Interest was increased by placing operators of smaller plants on the programs to describe their work.

"Frequently schools and sections hold their meetings at the same place and on successive dates. Efforts should be made to distinguish between the elementary instruction of the school and the experience subjects of the convention. Each has its value but the activity of one should not be permitted to interfere with the purposes of the other.

"A critic recently said that the water works man is too modest concerning his own work and kept his light under dark cover, and added that the public would be amazed if it could be made aware of the magnitude and value of his work to the community. This expression is worthy of thoughtful consideration.

"The membership should not forget, nor be unmindful of, the interest and cooperation of the Water Works Manufacturers Association. In all their dealings with this institution, they have been

courteous and helpful. The Association appreciates this attitude and looks to the future with confidence of continued friendly relations.

"The Association headquarters office is efficiently managed. Excellent data are continually accumulating. Correspondence is promptly attended to and kept up to date. Calls for assistance are answered. Advice is cheerfully given and with the utmost courtesy. The success of this institution depends upon these qualities in its secretarial work.

"The Association is definitely on its way. With your continued support, it is bound in due time to attain its objectives."

Presentation of Awards

Honorary Membership in the Association was conferred upon Frank A. Barbour, Carleton E. Davis, Charles Gilman Hyde, Beekman C. Little and Harry E. Jordan. The citations were:

Frank A. Barbour, Consulting Engineer, of Boston, Massachusetts, a member of the A. W. W. A. since 1906, its President in 1936, conspicuous for his keen discernment of engineering values, unflagging in his leadership in the affairs of water works men;

Carleton E. Davis, Manager of the Philadelphia Suburban Water Company at Bryn Mawr, Pennsylvania, a member of the A. W. W. A. since 1912, its President in 1920, nationally recognized as an able administrator in the field of public water supply, whose earlier services to the Association contributed materially to its present standing;

Charles Gilman Hyde, Professor of Sanitary Engineering in the University of California at Berkeley, California, a member of the A. W. W. A. since 1907, presently chairman of the Water Purification Division, a leader and teacher of men whose influence is nation-wide;

Beekman C. Little, Secretary Emeritus of the Association, resident in Rochester, New York, a member of the A. W. W. A. since 1903, its President in 1921, its Secretary from 1926 to 1936, a genial leader of men whose organizing ability contributed materially to the present standing of this organization;

Harry E. Jordan, Secretary of the Association since 1936, resident in New York, a member of the A. W. W. A. since 1919, Secretary to the Water Purification Division from 1923 to 1935, President of the Association in 1935, Diven medalist in 1936.

The John M. Diven Medal, annually awarded to the member whose services to the Association are deemed most outstanding, was presented to Hallett F. Smith, of Detroit, with the following citation:

> *Hallett F. Smith*, of the Department of Water Supply of Detroit, Michigan, for his leadership of members of this Association, stimulating them to the fine cooperative activity which made possible the preparation of the Manual of Water Works Accounting in its present commendable and useful form.

The John M. Goodell award, for the best paper published in the Journal of the Association, was presented to:

> *David G. Thompson* and *Albert G. Fiedler* for their paper entitled "Some Problems Relating to Legal Control of Use of Ground Water," presented at the New Orleans convention and published in the Journal for July, 1938. The paper is thus selected because it combines wide research and interpretive scholarship in the presentation of a study of great importance to public water supply practice.

George W. Fuller Memorial award certificates were presented to eighteen awardees. The citation for each follows:

> California Section, *Gerald Eugene Arnold*—"Most active as a member of the committee in charge of short course for water works operators conducted at the University of California, in which he served as chairman of the committee on curriculum and as a member of the lecturing staff."

> Canadian Section, *Abraham Martin Bowman*—"For efficient service in the administration of a water works system in a municipality of small size, involving initiative in the solution of problems and full adherence to the requirements of public service."

> Central States Section, *Edward Carey Trax*—"He has operated his large water purification plant according to the best standards and helped to train many other young men in proper operation practice. He has kept the directors of the city government and the citizens informed concerning the importance of the water works and the water purification system."

Florida Section, *Alvin Percy Black*—"In recognition of his outstanding work, both laboratory and field, in improving the theory and technique of water treatment in Florida."

Four States Section, *James Wadsworth Armstrong*.—"For his long and distinguished service in the design of water purification plants."

Illinois Section, *John Robert Baylis*—"For his outstanding contributions to the theory and practice of water treatment."

Indiana Section, *Howard Albert Dill*—"In recognition of his outstanding service to the water works fraternity of Indiana and to the country at large. As an outstanding public spirited citizen of the community in which he lives, he has endeared himself to his associates."

Michigan Section, *Hallett Francis Smith*—"For his outstanding work in connection with the Accounting Manual."

Missouri Valley Section, *John William Pray*—"He has been zealous in improving service and quality of water, and at the same time keeping the finances of the water works on a sound basis . . . has taken a very active leadership in the efforts to secure legislation aimed at employment of water works personnel on a merit basis and assuring security in tenure and pension."

Montana Section, *Frederick Elisha Brandis*—"One who has performed meritorious work in improving the water works service in the community in which he resides. He is one of the pioneers in the water works field in Montana."

New Jersey Section, *William George Banks*—"For meritorious work in planning and executing extensive improvements to the water supply system of the City of Newark. This work included the relining of aqueducts, thereby increasing their life many years; also strengthening of the entire distribution system."

New York Section, *Elon Powell Stewart*—"For the paper entitled 'Installation of a Fifty-four Inch Steel Intake Line for Syracuse,' and more especially for energetic and outstanding ability in the supervision of the public water supply of a major community."

Ohio Section, *Wendell Richard LaDue and Willard Charles Lawrence*—"For devoted and sustained efforts, beyond the obligations of their office, in the effective organization of the new Ohio Section, American Water Works Association."

Pacific Northwest Section, *Alexander Lindsay*—"Because of his meritorious contribution to the science of underground water supply engineering in the water supply development for the City of Spokane."

Rocky Mountain Section, *Dana Ewart Kepner*—"The pioneer and the organizer of the Rocky Mountain Section of the American Water Works Association. . . . assisted in the formation of the Water Works College which is held annually in conjunction with the Section meeting."

Southeastern Section, *Albert Andrew Passolt*—"In recognition of outstanding service and constructive leadership in the upbuilding of water supply standards in the Southeastern Section of the American Water Works Association, the State of Georgia and the City of Newnan."

Southwest Section, *Frank Walther Eduard Weisse*—"In recognition of his work on simplification of meter registers."

Wisconsin Section, *Leon Albert Smith*—"For his untiring efforts in promoting and welding into an active association, the water works men of Wisconsin."

The Nicholas S. Hill cup, awarded annually to the Section whose per cent of membership growth from one general convention to the next is highest, was won by the West Virginia Section. Its percentage gain was 117.4. Following in order were the Ohio Section

(52.5 per cent gain), the Minnesota Section (41.3 per cent gain) and the Michigan Section (28.0 per cent gain).

The Henshaw cup, awarded annually to the Section at whose annual meeting the largest per cent of its membership was present, was won by the North Carolina Section. Its per cent attendance was 90.18. There followed the Montana Section (89.69 per cent), the Minnesota Section (87.64 per cent) and the Pacific Northwest Section (86.49 per cent).

A special award was given at Atlantic City to the Section having the largest mileage-travel-persons-present at the convention. This award, a special banner and a grant of two active membership fees for a year, was won by the Southeastern Section.

A new and unique award, the Old Oaken Bucket, was given to the California Section as the Section having the largest total membership. This trophy will remain in the possession of the California Section until some other Section achieves a greater membership total.

Entertainment and Exhibits

Atlantic City naturally attracted many members who combined the technical features of the convention with the recreational features of the seashore resort.

Through the cooperation of Messrs. Biddle of the Pennsylvania Railroad and Mumford of the Statler Hotels, a group of more than 125 attended the World's Fair in New York after the convention was over. The customary pre-convention special train, which so largely depends upon the New York metropolitan group for patronage, did not operate because of the proximity of Atlantic City. Arrangements were made to accommodate those using train service from the west, but it appears that not more than 200 of the 1290 total registrants used train service to reach Atlantic City. Convention general entertainment began with an informal get-together in the Music Room of the Chelsea Hotel on Sunday evening. The President's reception and dance on Monday evening, the All-Section Dinner on Tuesday evening, a Monte Carlo on Wednesday evening and a Dinner and Dance on Thursday evening afforded ample general entertainment. For the ladies were provided a chair ride on the boardwalk on Tuesday, a bathing party on Wednesday and a luncheon-bridge on Thursday.

The New Jersey Section held a luncheon on Monday and on

Wednesday both the Finance and Accounting Division and the Water Purification Division held luncheons.

The exhibits in the auditorium covered more ground than has ever been used by an A. W. W. A. show. J. Herman Smith, chairman of exhibits, sold more than 13,000 feet net of exhibit space. Attendance at the exhibits, as well as at the technical sessions, clearly demonstrated the value of separating the hotel-housing from exhibits and meetings.

Technical Program

GENERAL SESSION—9:30 A.M.—JUNE 12, 1939

President's Address ..... Reeves Newsom
Social Security for Water Works Men ..... Dale L. Maffitt
Discussion ..... W. W. Brush
Progress in Electrical Grounding Research ..... C. F. Meyerherm
Discussion ..... G. A. Sampson
Labor Relations in the Water Works Plant ..... Leo Wolman
Discussion: The New Law of Design for Cast Iron Pipe .. Led by W. D. Moore

PLANT MANAGEMENT AND OPERATION—2:00 P.M.—JUNE 12, 1939

Wholesale Cost of Water ..... C. H. Capen, Jr.
Water Quality Complaints and Their Interpretation ..... W. C. Lawrence
Potential Health Hazards in the Distribution of Water to Consumers
Arthur E. Gorman
A Safety Code for Water Distribution ..... Wm. E. Stanley
Maintaining Proper Charges for Private Fire Protection ..... D. D. Gross
Discussion ..... John B. Winder

PURIFICATION DIVISION—2:00 P.M.—JUNE 12, 1939

Committee Reports

Methods of Determining Fluorides ..... Prof. A. P. Black
Specifications and Tests for Water Purification Chemicals
Prof. M. M. Braidech
Testing of Zeolites ..... Charles P. Hoover
Progress Reports
High Rate Treatment ..... Norman J. Howard
Conditioning Methods to Inhibit Corrosion .... Prof. W. F. Langelier
Activated Carbon Research ..... Prof. M. M. Braidech
Co-ordination of Methods of Water Treatment and Laboratory Control
Geo. D. Norcom
The Aging of Reservoir Waters ..... Lee T. Purcell
Discussion ..... Arthur H. Pratt and Robert Spurr Weston
An Iodide Technic for the Colorimetric Determination of Chlorine in Water ..... F. W. Gilcreas
Discussion ..... George E. Willcomb

GENERAL SESSION—9:30 A.M.—JUNE 13, 1939

Basic Principles in the Design and Operation of Earth Dams..Wm. P. Creager
Discussion.....Frank A. Barbour
Recovering from the Recovery Program.....Carl H. Chatters
Discussion.....Abel Wolman
The Importance of a State's Water Resources.....Hon. A. Harry Moore
New Jersey's Peculiar Problem.....George S. Burgess

PURIFICATION DIVISION—9:30 A.M.—JUNE 13, 1939

Fundamentals of Water Pre-Treatment.....Frank Bachmann
Discussion.....Led by Robert W. Furman
Experiences with the Coagulation of Soft, Colored Water by Ferric Sulfate
Geo. E. Willcomb
Discussion.....Led by Elwood Bean and A. H. Ullrich
Illinois's Experiences in Lime Softening with Short Time Upward Flow Clarification.....C. W. Klassen and H. A. Spafford
Performance of Upward Flow Basins at St. Petersburg, Florida
Robert W. Sawyer

GENERAL SESSION—2:00 P.M.—JUNE 13, 1939

Methods for Determining Water Hammer Pressure
F. M. Dawson and A. A. Kalinske
Water Hammer Studies on Long Pipe Lines.....Laurance E. Goit
Water Hammer Control by Proper Valve Installation.....E. C. Brisbane
Vertical Pump Applications.....Jule H. Coffey
Round Table—Specifications for Deep Wells and Deep Well Pumps
Led by James C. Harding and J. Arthur Carr

FINANCE AND ACCOUNTING DIVISION—2:00 P.M.—JUNE 13, 1939

Symposium on the Activities of the National Association of Railroad and Utilities Commissioners
Standard Methods of Filing Rate Schedules.....M. F. Hoffman
Standard Classification of Accounts and Standard List of Retirement Units.....Louis D. Blum
Commission Jurisdiction Over Water Works.....Jacob Schwartz
Round Table—The Accounting Manual.....Leader, Boyd A. Bennett

GENERAL SESSION ON MANAGEMENT AND ACCOUNTING—9:30 A.M.—JUNE 14, 1939

Service Lives of Water Mains as Indicated by a 75-Year Retirement Record
Reeves Newsom and E. H. Aldrich
Inspection Methods for Determining Pipe Condition
K. H. Logan and E. A. Koenig
Planning the Budget for Municipally-Owned Water Works...J. P. Schwada
Planning Water Works Property Development.....C. J. Alfke
Discussion.....Roger W. Esty
Administrative Problems of Joint Collection of Water and Sewage Charges—A Committee Report.....Frank O. Wallene

PURIFICATION DIVISION—9:30 A.M.—JUNE 14, 1939

Symposium on Water Quality

General Statement.....Geo. D. Norcom
Standards of Raw and Treated Water Quality.....H. W. Streeter
Water-Borne Gastro-Enteritis.....C. R. Cox
Bacteria from Chlorinated Waters
Prof. Max Levine, J. M. Coblentz and Philip Carpenter
Factors Affecting the Efficiency of Chlorination
Dr. F. C. Schmelkes, Elizabeth S. Horning and Geo. A. Campbell

GENERAL SESSION ON PURIFICATION—9:30 A.M.—JUNE 15, 1939

Further Notes on Cast Iron Pipe Corrosion and Its Control...Thos. H. Wiggin
The Correlation Between the Carbon Dioxide and Mineral Content of Water and Its Corrosivity.....Prof. Willem Rudolfs and T. T. Wong
The Threshold Treatment of Municipal Water Supplies
Owen Rice and G. B. Hatch
Super-Chlorination Practice in North America.....Harry A. Faber
Recent Experiences with Carbonaceous Zeolites.....S. B. Applebaum
Discussion.....A. S. Behrman

FINANCE AND ACCOUNTING DIVISION—9:30 A.M.—JUNE 15, 1939

Recent Decisions and Rulings Concerning Water Works..John H. Murdoch, Jr.
Water Bills as a Lien Against Property.....H. L. Meites
Maintaining Public Confidence.....Thad. M. Erwin and M. F. Hoffman
Increasing the Efficiency of Water Systems.....A. T. Cook
Discussion.....W. R. LaDue

PLANT MANAGEMENT AND OPERATION DIVISION—2:00 P.M.—JUNE 15, 1939

Developing Meter Specifications.....S. F. Newkirk, Jr.
Developing Distribution System Records.....W. V. Weir
Service Line Materials—A Progress Report.....Walter A. Peirce
Applicability of Various Service Line Materials.....E. Sherman Chase
Round Table Discussion: Application of Cathodic Protection to Water Towers and Tanks.....Led by W. W. Morehouse

Section Meeting Dates—1939

Section	*Meeting Place*	*Date*
California	San Francisco, Calif.	Oct. 25, 26, 27, 28
Canadian	Toronto, Canada	Apr. 12, 13, 14
Florida	Miami, Fla.	May 4, 5, 6
Four States	Reading, Pa.	Oct. 5, 6
Illinois	Urbana, Ill.	Apr. 20, 21, 22
Indiana	Indianapolis, Ind.	Apr. 25, 26
Kentucky-Tennessee	Memphis, Tenn.	Apr. 10, 11, 12
Michigan	Lansing, Mich.	Sept. 20, 21, 22
Minnesota	Duluth, Minn.	Aug. 24, 25, 26
Missouri Valley	No scheduled meeting	
Montana	Great Falls, Mont.	Apr. 14, 15
New England	No scheduled meeting	
New Jersey	New Brunswick, N. J.	Feb. 7
	Atlantic City, N. J.	Oct. 20, 21
New York	Rochester, N. Y.	Mar. 30, 31
	Utica, N. Y.	Nov. 2, 3
	New York, N. Y.	Dec. 28
North Carolina	Charlotte, N. C.	Nov. 6, 7, 8
Ohio	Dayton, Ohio	Apr. 27, 28
Pacific-Northwest	Tacoma, Wash.	May 11, 12, 13
Rocky Mountain	Denver, Colo.	Sept. 18, 19, 20
Southeastern	Spartanburg, S. C.	Apr. 17, 18, 19
Southwest	Dallas, Tex.	Oct. 16, 17, 18, 19
Virginia	Charlottesville, Va.	Sept. 7, 8
West Virginia	Morgantown, W. Va.	Oct. 12, 13, 14
Western Pennsylvania	Johnstown, Pa.	Sept. 18, 19, 20
Wisconsin	Oshkosh, Wis.	Oct. 30, 31, Nov. 1

Resumé of 1939 Section Meetings

There follows a summary-listing of papers scheduled for Section meetings. A table (page 2208) showing dates and places of Section meetings and a list (page 2220) of Section officers elected at meetings held during 1939 and who were holding office on January 1, 1940 are included.

California Section—Scheduled Papers

New Water Softening and Filtration Plant of the Metropolitan Water District of Southern California ..... J. M. Montgomery and Wm. W. Aultman
Discussion ..... Led by N. R. Collins and Arthur Taylor
Symposium: The Practical Aspects of Internal Corrosion
Louis J. Alexander, Robert R. Ashline, Oscar C. Blumberg and H. A. Knudsen
San Francisco Water Department—General Description and Problems, With Reference to Water Supply for Treasure Island and Raising O'Shaughnessy Dam ..... Nelson A. Eckart
Cathodic Protection of Domestic Distribution System at Treasure Island
Charles H. Lee
Blocking as Practiced in the Los Angeles Distribution System
E. W. Breitkreutz
Silting in Reservoirs L. Standish Hall
Calcium Suppressive Compounds in Water Supply Treatment ..... Owen Rice
Discussion ..... Led by Dr. Carl Wilson
Recent Developments in the Removal of Salts from Water ..... Ray F. Goudey
Discussion ..... Led by R. B. Thieme and Harry Burrell
The Use and Limitations of Conductivity Measurements of Well Water Quality
Kenneth W. Brown
Discussion Led by H. C. Medbery
Address ..... J. Arthur Jensen
Mono Craters Tunnel—Construction Problems ..... H. L. Jacques
Symposium: Value of Water Department Records
(1) Legal Operation ..... W. G. Irving
(2) Plant Operation ..... Carl M. Hoskinson and Howard A. Harris
(3) Improvement Requirements ..... J. W. Ford and C. P. Harnish
(4) Public Relations ..... H. B. Fisher
Sanitary Standards for Hotels ..... Gerald E. Arnold

Canadian Section—Scheduled Papers

Chairman's Address ..... A. B. Manson
Water Works Intakes ..... N. G. MacDonald

Valuation of Water Works Systems
a. Canadian Practice ..... J. C. Keith
b. United States Practice ..... J. P. Wentworth
Some Phases of Public Relations for Water Works ..... V. A. McKillop
Some Features in Water Coagulation ..... H. P. Stockwell
Guided Discussions
Water Rates—Metered ..... R. H. Martindale, Chairman
Water Rates—Flat ..... C. E. Brown, Chairman
Water Pressures in Distribution Systems ..... L. F. Allan, Chairman
Rates for Water Sold to Outside Areas ..... W. L. McFaul, Chairman
Hydrant Maintenance ..... R. L. Dobbin, Chairman
Water Works Distribution Systems ..... Wm. Storrie, Chairman
Control of Tastes and Odors ..... N. J. Howard, Chairman
Reservoirs and Water Storage ..... W. B. Redfern, Chairman
Service Pipes ..... R. J. Smith, Chairman
Establishing Water Areas in a Municipality ..... F. G. Browne, Chairman

Florida Section—Scheduled Papers

American Water Works Association Affairs ..... Reeves Newsom
Recent Advances in Water Treatment ..... A. S. Behrman
Threshold Treatment of Water ..... Owen Rice
Theories of Soil Corrosion ..... Dr. James T. MacKenzie
Discussion ..... Frank Dickey, Harry M. Damerow and K. H. Logan
Uses of Transite Pipe in Cuba ..... Estefano Calcavechia
The Development of a Sewage Disposal Program ..... M. T. Singleton
The Pensacola Sewage Treatment Plants ..... O. J. Semmes, Jr.
Sewage and Trade Wastes Treatment in Cuba ..... J. A. Cosculluela
Coagulants in Sewage Treatment ..... L. L. Hedgepeth
The Miami Beach Ocean Sewage Outfall ..... M. N. Lipp
The New Water Supply of Bradenton ..... C. K. Dodd
The Hollywood Municipal Softening Plant ..... William Sydow
The Miami Water Supply, Past, Present, and Future ..... Alexander Orr
Plumbing Hazards and Their Evaluation ..... L. M. Fisher
Availability of Surface Water Sources ..... D. S. Wallace

Four States Section—Scheduled Papers

Use of the Meter-Master in Water Distribution Systems ..... Frank Brainard, Jr.
Effectiveness of Sand Filters in Removing Floc
G. B. McCall, S. E. Edwards and Edw. S. Hopkins
Gastro-Intestinal Derangement During Droughts ..... George G. Schaut
New Methods of Water Treatment at Reading, Pa. ..... W. Strockbine
A Study of the Regulations of the Bureau of Water Supply of Baltimore for Water Main Installations ..... Harvey T. Green
Jacking 72-inch Steel Multiple Plate Pipe under an Outfall Sewer
Ralph Sheperd
Bacterial Growths in Water Distribution Systems ..... Harry A. Faber
Cost Accounting and Its Relation to Water Supply ..... W. C. Thayer
From Rain Drops to Tap (Motion Picture) ..... W. A. Welch

ILLINOIS SECTION—SCHEDULED PAPERS

Ground Water Development from Gravel Filter Wells.....A. W. McLean
Construction and Use of Well Screens.....E. W. Benneson
Well Construction in Foreign Lands (Motion Picture)..Layne-Bowler Co.
Panel Discussion on the Improvement of Ground Water
Need for Improvement of Quality of Ground Water..Clarence W. Klassen
How Can Ground Water Be Improved.....Prof. A. M. Buswell
Improvement in Quality of Ground Water by Treatment by the Lime-Soda Method.....A. S. Behrman
Improvement in Quality of Ground Water by Treatment by the Zeolite Method.....William H. Mitchell
Steel, Man's Servant (Motion Picture).....U. S. Steel Corp.
Proposed Specifications for Strength of Cast Iron Pipe....Prof. M. L. Enger
Simplified Analysis of Head Loss in Water Pipe Distribution Systems
Prof. James J. Doland
Discussion.....Led by Frank C. Amsbary, Jr.
Experiences at Springfield, Illinois with Various Methods for Sterilization of New Water Mains.....S. T. Anderson
Electrolysis and Its Effect on Underground Structures.....K. P. Stiles
Bacteria, Corrosion and Red Water.....Dr. T. E. Larson
Two Years' Operation of Springfield, Illinois, Water Softening Plant
Charles H. Spaulding
Discussion.....Led by F. L. Coventry
The Morse Filter Plant.....Edward E. Alt
Discussion.....Richard A. Williams
Chicago's South District Filtration Project.....Loran D. Gayton
Swimming Pool Maintenance.....H. L. White
Swimming Pool Sanitation.....C. A. Hyatt

INDIANA SECTION—SCHEDULED PAPERS

Report of Committee on Operators District Schools.....C. D. Adams
Discussion.....B. H. Jeup and W. A. Oeffler
Water Works Improvements being made at Evansville, Ind...Louis A. Geupel
Comments on Certain Current Water Works Problems.....Reeves Newsom
Efficient Utilization of Water for Fire Fighting.....Clarence Goldsmith
Discussion.....Led by Frank C. Jordan
Report of Licensing Committee.....B. A. Poole
Discussion.....Prof. R. B. Wiley
Meter Settings and Controlled Compound of Meters.....L. S. Vance
General Discussion
Efficiency in Operation.....Harry E. Jordan
Adaptability of Various Pipe Line Materials in Water Main Construction
L. R. Howson
Recent Trends in Water Treatment.....H. E. Hudson, Jr.
Discussion.....J. C. Vaughn and L. I. Birdsall
Operation Investigations.....C. K. Calvert

KENTUCKY-TENNESSEE SECTION—SCHEDULED PAPERS

Address ..... Reeves Newsom
The Memphis Water System ..... J. J. Ryan
Methods for Iron Removal ..... A. P. Learned
Problems in Water Purification ..... R. P. Farrell
Centrifugal Pumps Designed for Underground Waters ..... A. O. Fabrin
Administrative Problems of Preventing and Correcting Defective Plumbing ..... A. H. Fletcher
Discussion ..... R. L. Lawrence
Transite Pipe ..... R. F. Orth

MICHIGAN SECTION—SCHEDULED PAPERS

The Water Department as an Independent Utility ..... D. C. Egbert
Handling and Feeding Carbon ..... Newton Powers
Guided Discussions:
The Small Water Department ..... James Galloway
Complaints, How They Are Handled ..... George Golden
Cross-Connections ..... W. C. Hirn
Maintenance of Electrical Equipment in the Water Works ..... C. J. Schoeninger
Special Media ..... Dr. W. L. Mallman
Stabilized Water—Hard or Soft ..... F. T. Redman
Guided Discussions:
Valves and Hydrants ..... James Hornshaw
Cathodic Protection for Water Works Equipment ..... W. D. Loreaux
Description of Lansing Conditioning Plant ..... O. E. Eckert

MINNESOTA SECTION—SCHEDULED PAPERS

Plumbing Cross-Connections ..... Felix Seligman
Trends in Water Works in 1939 ..... L. N. Thompson
Experiences with the Zapffe Catalytic Process ..... A. M. Kircher
Round Table Discussion of Water Problems ..... Leader—R. A. Thuma
Water Supply for Railways ..... Edwin M. Grime
An Evaluation of Cross-Connection and Back-Siphonage Protective Methods ..... F. M. Dawson
Stillwater, Minnesota, Water Works System Historic and Unique ..... Herbert S. Grove
The American Water Works Association ..... Norman J. Howard
The Effect of Disposal of Sewage and Industrial Wastes upon Surface Water Supplies ..... H. G. Rogers
The Meter-Master, The "G-Man" of the Water Works ..... Frank Brainard, Jr.
The Use of Activated Carbon at the Fargo Filtration Plant ..... Ora C. Ayliffe

MONTANA SECTION—SCHEDULED PAPERS

Another Slant on Relief Work ..... Emil Sandquist
Water Purification and Softening at Minneapolis ..... J. Arthur Jensen
A Year in the Great Falls Parks ..... Tom Lease

Great Falls City Water Supply System.....Ed Henen
Modern Methods of Sewage Treatment.....Rolf Eliassen
Electrolysis Study at Three Forks.....F. F. Palmer
Cathodic Protection of Underground Pipes.....Carl Davis

NEW JERSEY SECTION—SCHEDULED PAPERS—SPRING MEETING

Telling the Story of Water Treatment to a Non-technical Audience
Martin Flentje
Some Elements of Hydraulics and Application to Water Works Engineering
H. N. Lendall
Some Trouble-Makers in our Reservoirs
Dr. T. C. Nelson and Ralph H. Holtje
Limbo-Biology—A Hobby with a Practical Aspect. Illustrated
A. E. Griffin
The Villian Pursueth (Motion Picture).....Presented by E. A. Sigworth

NEW JERSEY SECTION—SCHEDULED PAPERS—FALL MEETING

Some Elements of Hydraulics and Application to Water Works Engineering
H. N. Lendall
The Reactions of Heavy Doses of Chlorine in Various Waters....A. E. Griffin
Definition of Unaccounted for Water.....George F. Wieghardt, Leader
Problems of the Small Water Works.....Edward P. Hyland, Leader
Experiences in New Jersey During the 1939 Drought..E. Vernon Smith, Leader
Water Pollution by Waste Petroleum Products.....Mortimer M. Gibbons
Well Construction in Foreign Lands (Motion Picture).....Layne-Bowler Co.
Interconnection Survey in Northern New Jersey.....George S. Burgess
Discussion.....Clyde Potts

NEW YORK SECTION—SCHEDULED PAPERS—SPRING MEETING

Studies of Bacterial Pollution of the Niagara River. Illustrated
Dr. George E. Symons
Discussion.....B. T. Dignan and R. D. Bates
Recent Developments in Photography.....Dr. C. E. Kenneth Mees
Engineering Aspects of Well Development.....Charles F. Jost
The Installation of 54-inch Steel Intake Line for Syracuse. Illustrated
E. P. Stewart
An Interesting Experience with W.P.A. Labor.....Earle J. Trimble
Development of the Webster Water System.....Meloy Smith
Distribution System Safety.....Prof. William E. Stanley
Reconditioning Large Water Mains.....H. Seaver Jones
Air Trapped Water Supply Mains.....C. E. Elmendorf
Problems in the Treatment of the Waters of Lake Ontario and Lake Erie
George D. Norcom, Henry F. Wagner and Paul Windt
Problems in the Treatment of Waters from a Flashy Creek.....E. A. Sterns
Problems in the Softening of Certain New York State Waters
F. D. West and R. G. MacDonald
Control of Tastes and Odors.....William Ryan

NEW YORK SECTION—SCHEDULED PAPERS—FALL MEETING

The Effect of the Hurricane on the Operation of Long Island Water Systems
N. F. Fenn
Filter Sand ..... Thomas M. Riddick
Water-shed Protection and Control—Syracuse Water Supply
Arnold F. Gregory
Difficulties in Water System Construction and Maintenance at Herkimer, N. Y. ..... C. Leland Wood
The Use of Copper Sulfate as an Algecide ..... George C. Hodges
Steel Pipe for Mains and Distribution ..... E. H. Thwaits
Water Districts—Pro and Con ..... Alexander Russell
Beneficial Results from and Construction Methods Used in Realignment of 60-inch Discharge Main ..... William H. Grotz
Ilion's Water Supply ..... Earle J. Trimble
The Handling of Liquid Chlorine and Chlorine Compounds ..... W. W. Highberger
Chlorination ..... Jeff Corydon, Howard Pardee and Lawrence J. Peck
Super-chlorination ..... Harry Faber and E. Gordon Yaxley

NEW YORK SECTION—SCHEDULED PAPERS—WINTER MEETING

Centralized Laboratory Control for a Group of Privately Owned Water Supplies ..... John S. Kneale
Regulation of Water Utilities in New York State ..... Arthur H. Pratt
Delaware Water Supply for the City of New York ..... Leonard P. Wood

NORTH CAROLINA SECTION—SCHEDULED PAPERS

Effect of Air-Conditioning on Water and Sewerage Facilities ..... W. M. Wallace
Description of Vest Station Water Purification Plant ..... G. S. Rawlins
Description of Catawba Pumping Station ..... J. L. Greenlee
Kier Liquor Reduction ..... R. S. Phillips
Water and Sewage Treatment ..... Linn H. Enslow
Round Table Discussion of Operating Problems of Sewage Treatment Plants
Dr. H. G. Baity (Chairman), George Moore, Joseph Henderlite, E. H. Moss, R. M. Rogers and Ralph Porges
Address ..... J. Arthur Jensen
Super-chlorination and Odor Control ..... A. E. Griffin
Types of Mixing Chambers and Flocculation ..... L. L. Hedgepeth
Round Table Discussion of Water Treatment Problems
P. W. Frisk (Chairman), Dan Ireland, Waymon Smith, F. G. Doggett, W. F. Parks, Jr., L. I. Lassiter and W. M. Franklin
Sound Movie—Uses of Aluminum Products in Water Works and Sewage Treatment Practice ..... H. A. Lilly
Lining Pipes in Place ..... Bruce Harkness

OHIO SECTION—SCHEDULED PAPERS

New and Used Water ..... W. W. Morehouse
Consumer Accounting and Collecting ..... M. J. Hoffman
Discussion ..... Frank Robinson

Legal Aspects of Water Works Operation with Special Reference to Liability of a Water Department For Damage Occurring from Leaks
Philip Burgess
Possibility of Utilizing the Conservancy Act for Developing Water Supply and Sewage Disposal ..... F. H. Waring
Discussion ..... W. W. Morehouse
Considerations of Distribution System Design for Adequate Fire Protection
George Tatnal
Discussion ..... Frank Tolles
Recent Developments relating to Chlorine
1. Processing and Packaging of Chlorine ..... L. L. Hedgepeth
2. Use of Chlorine in Water Purification ..... H. A. Faber
Discussion ..... John Gettrust
Water Comes to Main Street ..... A. E. Kimberly
Round Table Discussions ..... Prof. Geo. E. Barnes, Presiding
1. Service Materials ..... Paul Cook
2. Human Element in Emergencies ..... Carleton Finkbeiner
3. Meters ..... Paul Cook
4. Interior Coatings for Elevated Tanks ..... L. J. Hoffman
5. Experiences with Centrifugal Cast-Iron Pipe ..... C. E. Inman

Pacific Northwest Section—Scheduled Papers

Round Table Discussion:
1. Grounding of Electric Circuits on Water Pipes ..... J. B. Downer
2. New Devices in Water Works Operation ..... Hugh F. Fague
3. Breakdown of Financial Structure in Small Water Systems
L. E. Jarvis
4. Storeroom and Shop Facilities of the Tacoma Water Department
J. P. Pence
5. Studies in Pollutional Content Variations of Streams in Connection with Water Treatment ..... I. N. Carter
6. Water Department Planning for Small Cities ..... B. C. Gosney
7. Back Siphonage From Pumping Fixture Into Water Supply Lines (Film) ..... Carl E. Green and Roy M. Harris

Fluctuations in Ground-Water Level: Their Common Causes and Their Significance in Relation to Prudent Use of Groundwater Supplies
Arthur M. Piper
Cost to the Water Departments of Operating Sewers and Sewage Disposal Plants ..... R. F. McLean
Water Works Planning ..... Samuel B. Morris
Automatic Control of Pumping Plants in Spokane ..... Alex Lindsay
Recent Improvements in the Tacoma Water System ..... W. A. Kunigk
Round Table Discussion:
1. Meter Shop Practices ..... Fred D. Jones
2. Recent Improvements in the Tacoma Water System ..... W. A. Kunigk
3. Meter Shop Practices ..... Fred D. Jones
4. Main Contamination and Oakum Sterilization ..... M. S. Campbell

5. Copper Service Replacements and Installation ..... J. C. Strudgeon
6. Recommended Practice in Obtaining Samples for Bacterial Analysis
Ben L. Grimes, Jr.

ROCKY MOUNTAIN SECTION—SCHEDULED PAPERS

Progress of Grand Lake Diversion Project ..... Porter Preston
Discussion ..... L. C. Osborn
Treatment of Water for Fluoride Removal ..... Robert J. Owens
Discussion ..... Joe King
Water Rates ..... William A. Peters
Discussion ..... K. E. Darling
Water Softening ..... Dana E. Kepner
Discussion ..... C. P. Hoover
Hydraulics of the Parshall Flume ..... Ralph Parshall
Design of New Water Filter Plant at Grand Junction ..... F. M. Veatch
Discussion ..... J. P. Soderstrum
The Use of Activated Carbon ..... O. J. Ripple
Discussion ..... D. P. Porter
Taste and Odor Control ..... Lloyd Billings
Open Discussion
Cross-Connections ..... Robert J. Portman
Discussion ..... William Buhler
Mineral Hot Springs Waters ..... E. M. Howell
Open Discussion
Bacteriology of Waters ..... Dudley Peters Glick
Discussion ..... George A. Schlitt
Photo-Micrographs of Micro-Organisms ..... George J. Turre
Discussion ..... Chester A. Truman
Address ..... J. Arthur Jensen
The Water Works G-Man ..... Frank Brainard, Jr.
Value of Laboratory Control ..... Roy Seaman
New Law on Water and Sewerage Districts ..... William Cheek
Licensing of Water Superintendents and Plant Operators ..... B. V. Howe

SOUTHEASTERN SECTION—SCHEDULED PAPERS

The American Water Works Association ..... Reeves Newsom
W.P.A. Water and Sewage Projects in South Carolina ..... A. V. Hooks
Informal Round Table Discussion—Short Water Schools and Certification of Water Plant Operators ..... W. H. Wier and Guy H. White
Pipe Lining ..... Charles D. Turner
Methods of Determining Wall Thickness of Steel Pipe ..... R. E. Barnard
Pipe Coefficients ..... Lowell Cady
Stream Pollution ..... R. E. Tarbett

SOUTHWEST SECTION—SCHEDULED PAPERS

Saving Money for the Tax-payers ..... T. L. Amiss
Advisability and Methods of Checking Private Water Supplies ..... O. M. Baake
The Denison Dam ..... Captain Lucius D. Clay

Dealing with the Public ..... Joe J. Murray
Keeping Filter Sand Clean ..... Thomas C. Green
Filter Washing Theory ..... Edward R. Stapley
The Advantages of Metaphosphates over CO_2 for recarbonation in lime softened Water ..... Owen Rice
Discussion ..... D. B. Dickson
Distribution System Practices ..... D. W. Robinson
Transite Pipe—a motion picture
The Hays Process Plant ..... Clyde C. Hays
Discussion ..... E. W. Steel
High Capacity Trickling Filters ..... Lee H. Powell
Discussion ..... H. L. Dabney
Treatment Plant for Dallas ..... R. M. Dixon
Discussion ..... W. S. Mahlie
Control of Bulking in Activated Sludge Process ..... E. M. Berg
Discussion ..... W. E. White
Mineral Composition of the Waters of Oklahoma ..... Prof. Otto M. Smith
Super-chlorination for Taste and Odor Control ..... J. M. Lloyd
Discussion ..... A. E. Griffin
Cast-Iron Pipe in Long Time Service (a motion picture) ..... Lester Long
Mapping Water Works Structures ..... W. V. Weir
Discussion ..... Henry E. Nunn
A City's Legal Responsibility for the Operation of Municipally-owned Water Works ..... H. P. Kucera
W.P.A. for Water Works and Sewers ..... E. A. Baugh
City Planning and How It Affects Water Works ..... E. A. Wood
Factors Affecting Efficiencies of Various Types of Deep Well Centrifugal Pumps ..... E. O. Fabrin
Developing Resources in the Southwest ..... Dr. E. P. Schoch
Biological Balance for the Control of Tastes and Odors ..... Dr. B. B. Harris
Discussion ..... Dr. J. K. G. Silvey
Discussion ..... W. M. Longnecker
Stream Pollution Control in Protecting the Quality of Water Supplies
Chester Cohen
Discussion ..... Paul Henderson
Unaccounted-for Water ..... R. B. Thomas
Discussion ..... J. L. Horner
Policies of Handling Private Fire Lines ..... W. D. Masterson
Discussion ..... G. L. Fugate
Unusual Experiences with a Water Works System
Roy Mathews, E. C. Johnson, Charles Collins,
B. G. Cole, R. C. Dohe, L. A. Grimes, and others
Operating Conditions of a Water Works—Motion picture ..... L. A. Jackson
Experience in Developing Submerged Combustion Recarbonation Equipment
L. H. Scott
Discussion ..... A. H. Ullrich
Water Needs of Texas and the Southwest ..... V. M. Ehlers
Cutting Cost of Operation and Maintenance in Water Works ..... W. F. McMurry

VIRGINIA SECTION—SCHEDULED PAPERS

Results of New Ideas at Fredericksburg ..... Roland J. Leveque
Public Relations ..... D. R. Taylor
Corrosion, Its Cost and Cure ..... R. L. Blankenship
Importance of Sampling and Studying the Water in the Distribution System
A. T. Lundberg
Relation of the State Department of Health to Public Water Supplies
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A21.1-1939

American Recommended Practice

MANUAL FOR THE COMPUTATION OF STRENGTH AND THICKNESS OF CAST IRON PIPE

Approved by
American Standards Association
December, 1939

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

FOREWORD

On September 10, 1902, the New England Water Works Association adopted Standard Specifications for Cast Iron Pipe and Special Castings. These covered bell and spigot pipe and fittings and contained ten classes, A to K. The allowable heads for these classes were not given in the specifications but the thicknesses were based on allowable heads varying by 50 feet; 50-ft. head for Class A, 100-ft. head for Class B, up to 500-ft. head for Class K. Fairly complete dimensions were given, also weights of pipe and fittings.

In 1904 the American Society for Testing Materials adopted Standard Specifications for Cast Iron Pipe and Special Castings. These covered bell and spigot pipe and fittings and contained four classes, A to D, with allowable working heads varying by 100-ft.; 100-ft. head for Class A to 400-ft. head for Class D. Dimensions and weights of pipe were given.

On May 12, 1908, the American Water Works Association adopted Standard Specifications for Cast Iron Pipe and Special Castings. These covered bell and spigot pipe and fittings and contained eight classes, A to H, with allowable working heads varying by 100 feet; 100-ft. head for Class A to 800-ft. head for Class H. Fairly complete dimensions were given, also weights of pipe and fittings. Classes A to D were the same in thickness as in the A.S.T.M. Specifications.

The Sectional Committee (A21) on Specifications for Cast Iron Pipe and Special Castings, which developed the specifications contained herein, was organized in 1926 under the rules of the American Engineering Standards Committee, now the American Standards Association. The sponsor societies are the American Gas Association, the American Society for Testing Materials, the American

Water Works Association and the New England Water Works Association. Committee A21 was assigned the following scope:

> "Unification of specifications for cast iron pipe, including: materials; dimensions; pressure ratings; methods of manufacture (including such new developments as centrifugal casting), in so far as they may be necessary to secure satisfactory specifications; elimination of unnecessary sizes and varieties; consideration of the possibility of developing a coordinated scheme of metallic pipe and fittings applicable to all common mediums; and methods of making up joints in so far as they are determining as to the dimensional design of cast iron pipe.
>
> The types of cast iron pipe to include: bell and spigot pipe; flanged pipe; flanged and bell mouth fittings and wall castings; pipe elbows, tees, Y's, return bends and other fittings not now included in standard lists; cast iron pipe threaded for flanges or couplings; soil pipe and other light types of cast iron pipe and fittings. The standardization is not to include methods of installing pipe and similar matters, except as to the making up of joints in its relationship to the dimensional standardization of pipe and fittings, as noted above."

At the Committee's request soil pipe was assigned to another committee. Screw fittings have been omitted from the work of the Committee.

The specifications which follow herein apply only to Pit Cast Pipe for Water or Other Liquids and include an allowance for water hammer. A similar set of specifications has been prepared covering Cast Iron Pit Cast Pipe for Gas. Committee A21 has in preparation specifications, which will be issued from time to time as completed, covering Special Types of Pipe, Bell and Spigot Fittings, Flanged Pipe and Fittings, Coatings and Linings.

Committee A21 has had the benefit of a fund for tests and research, provided largely by the producers. Records of tests made and conclusions drawn have been or will be published in separate volumes. These tests include tests of corrosion of different kinds of cast iron; tests of pipe under combined earth and infernal pressures, upon which designs of barrel of pipe have been based; tests of hydraulic friction losses in fittings; bursting tests of pipe and fittings; tests of holding strength and deflection of bell and spigot joints; tests of lugs and harness for bell and spigot joints; tests of welded clips for use with harness. The publications already issued and those projected are listed.

Publications Developed under the Committee's Direction

Investigation of Bell and Spigot Joints in Cast Iron Pipe. By John C. Prior, January, 1935, being Bulletin No. 87, Engineering Experiment Station, Ohio State University; 57 pages, price 50 cents.

Part 1—Pull Out Strength; Part 2—Bell Strength; Part 3—Harness Strength.

Note: Work participated in by Cast Iron Pipe Research Association, City of Columbus, Ohio, and Committee A21.

Long versus Short Body Fittings for Water Supply.

Part I—Loss of Head Caused by Bends, Tees and Crosses. By Ernest W. Schoder and Arthur N. Vanderlip.

Part II—Economic Comparison. By Allen T. Ricketts and Thos. H. Wiggin.

Cornell University Engineering Experiment Station, Bulletin No. 20, September, 1935. 102 pages; Price $1.25.

Report of Tests to Determine the Shearing Strength of Steel Anchor Clips Bronze Welded to Cast Iron Pipe.

By W. J. Krefeld, Engineer of Tests, Civil Engineering Laboratories, Columbia University in New York City, with Memorandum by Leonard P. Wood of Committee A21. Published in 1936 by Committee A21, 18 pp., 25 cents.

Strength and Elastic Properties of Cast Iron.

By W. J. Schlick and Bernard A. Moore. Bulletin 127, Iowa Engineering Experiment Station, June, 1936; 95 pages.

(Note: Work described was mostly not done for Committee A21 but was related to it, done in same period and shows some correlations with results of work done for Committee A21.)

Publications Projected

Bulletin of University of Illinois, Engineering Experiment Station, describing bursting tests, beam tests and many other miscellaneous tests on cast iron pipe and fittings. By Dean M. L. Enger.

Bulletin of Iowa State College, describing tests of cast iron pipe supported in various ways and with exterior loads only or with various combinations of exterior load and interior pressure applied simultaneously. By W. J. Schlick.

Corrosion Tests of Cast Iron of Various Chemical Compositions.

Work done at Massachusetts Institute of Technology.

From the tests and research a new theory of design was developed in which not only static water pressure and water hammer but also earth pressure and load from trucks are included in computations for thickness; also different methods of laying, i.e., pipe supported on blocks or on trench bottom, with or without tamping of backfill and with various depths of earth cover. The specifications (A21.2 – 1939) give thicknesses for some of these laying conditions. This Manual describes the principles and methods of computing pipe thicknesses, and of estimating trench and truck loads.

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PREFACE

This Manual is intended primarily to explain the new principles and methods which have been used by Sectional Committee A21 in the computation of standard pipe thicknesses which are included with the specifications for pit cast and other types of cast iron pipe. These principles and methods are of general application to cast iron of any strength and Part 1 of the Manual shows how the methods may be used to compute the necessary thickness of a pipe under known conditions of internal pressure, earth cover and method of laying, for any specified strength of iron.

Diagrams of earth load, truck super load, ratio to 3-edge bearing and other data used in computing and fixing thicknesses in the specifications, as well as data which may be used for conditions other than those covered by the specifications, are included in the Manual.

In Part 2 of the Manual the particular application of the methods for computing barrel thickness described in Part 1 is made to Cast Iron Pit Cast Pipe, cast with iron having the strength assumed in the specifications therefor; and Appendix 2A of Part 2 gives extended tables of thickness for Cast Iron Pit Cast Pipe for Water or Other Liquids. These extended tables include a greater range of cover than Tables 1 through 4 of the specifications and also include thicknesses for two additional methods of laying which are little used as yet but are of possible interest to the pipe-user under certain special conditions. Additional parts of the Manual containing data on other types of pipe will be issued when specifications for the other types of pipe are completed.

It is the intention to add to the Manual any data which the Committee shall believe necessary for a proper understanding and use of any of the specifications for straight pipe, for fittings or for coatings which may be produced by the Committee in fulfilment of its assigned scope or for intelligent use of the Manual.

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MANUAL

Part 1

Method of Computing Thickness of Barrel of Cast Iron Pipe

Sect. 1-1. New Factors in Design of Cast Iron Pipe

The method used in computing thickness of pipe in the schedules contained in the specifications of which this Manual is explanatory is based both on tests made for Sectional Committee A21 and on many earlier tests made at the Iowa State College on sewer pipe and culverts. The earlier tests developed the magnitude of the backfill loads transmitted to pipe laid in ditches or under road embankments, and of the load added by vehicles superimposed on the backfill, also the effect of various methods of supporting the pipe and the effect of tamping and not tamping the backfill.

The tests made for Committee A21 carried the Iowa State College investigations a step further by the inclusion of internal pressure applied simultaneously with external earth load to pipe supported in various ways and with backfill tamped and not tamped. An additional method of support, beyond those previously included at Iowa State College was introduced, viz., by blocking which is used by some constructors for water and gas pipe but not used for sewer pipe.

Sect. 1-2. Methods of Laying, or "Field Conditions," Considered

Four common and two uncommon methods of laying cast iron water pipe and gas pipe were selected as covering conditions met with at present or likely ever to be met with in case of pipe laid in trenches having approximately vertical sides. These were named "field conditions" and are as shown on the following page.

FIELD CONDITIONS

Field Condition	Explanation
A	Flat bottom trench, backfilling not tamped.
B	Flat bottom trench, backfilling tamped.
C	Pipe supported on blocks, backfilling not tamped.
D	Pipe supported on blocks, backfilling tamped.
E	Bottom of trench shaped to fit bottom of pipe for about 90° (unevennesses filled in by sand as required), backfilling not tamped.
F	Same as E except that backfilling is tamped.

Field conditions E and F are common for sewer pipe but have been rarely used for cast iron water and gas pipe though the superior strength of pipe so laid has caused some increase in the use of this practice for pipe lines.

Another condition, viz. pipe under embankment, will be treated in an appendix (not yet prepared).

Sect. 1-3. Law of Behavior of Pipe under Both External Load and Internal Pressure

The tests made for Committee A21 showed that, when a pipe has both an external load applied in 3-edge bearing (see Sections 1–4 and 1–5) and an internal pressure, the relation between the external load and the internal pressure at the point of breaking can be represented with sufficient accuracy for various combinations of internal pressure and trench load by a parabola drawn as in Fig. 1.

The load-pressure curve (Fig. 1), employed either graphically or algebraically by use of its equation, is the basis of the whole system of barrel thickness computation used by Com. A21. It was initially the work of Prof. W. J. Schlick of Iowa State College, the institution employed by Com. A21 to make its tests on combined earth load and internal pressure.

Sect. 1-4. Equation of Load-Pressure Parabola and Values of Constants in Equation

The equation of the load-pressure parabola may be expressed,

$$w = \frac{W}{\sqrt{P}} \sqrt{P - p}$$

where the letters signify quantities in relation to the parabola as explained in Sect. 1-3 and Fig. 1. A definite equation may be written for any pipe for which P and W are known and these may be computed from the formulae given below using breaking strengths determined by crushing and bursting tests.

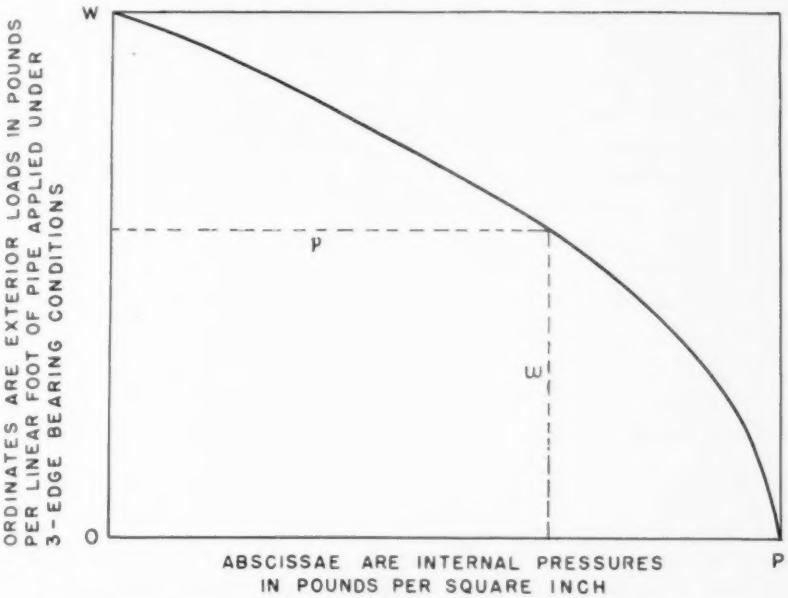


FIG. 1. Load-Pressure Curve.

EXPLANATION: Load-Pressure Curve is a parabola with apex at P. P is the bursting pressure of the pipe when no earth load exists. W is the crushing load per linear foot of pipe in 3-edge bearing when no internal pressure exists. p and w are any combination of internal pressure and external load which will just cause fracture. For equation of parabola and values of P and W see Sect. 1-4.

P, the bursting pressure of the pipe in lb. per sq.in., is found by the usual cylinder formula,

$$P = \frac{2tS}{d}$$

where t is the thickness of the pipe,

S is the bursting strength in lb. per sq.in. of the metal in the pipe, as determined by bursting tests of full lengths of pipe having metal of the same kind.

d is the internal diameter of the pipe in inches.

W, the crushing load in lb. per lin. ft. of pipe supported in 3-edge bearing, is found by the following formula.

$$W = \frac{t^2 R}{.0795\ (d + t)} \text{ **}$$

where t is the thickness of the pipe in inches,
d is the internal diameter of the pipe in inches,

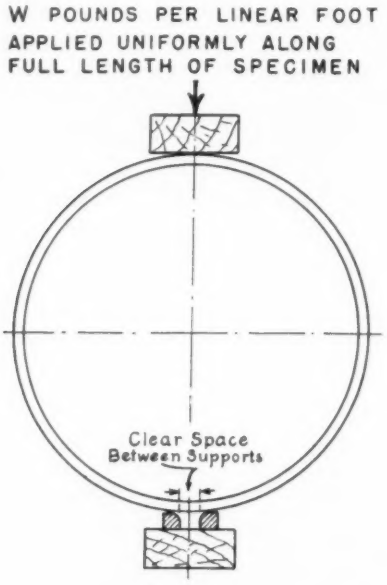


FIG. 2

NOTE—The condition of loading shown in fig. 2 is usually called, and is called in the specifications and Manual of Committee A21, the "three-edge bearing load" because two supports close together are used to facilitate the laboratory test work by keeping the specimen from rolling on the table of the testing machine.

and R is the modulus of rupture in lb. per sq.in. of the metal in the pipe as determined by crushing tests of specimens of pipe having metal of the same kind, the pipe being loaded as shown in Fig. 2.

** This formula is approximate since the deflection, y, is omitted, but is near enough for designing purposes. The accurate formula is:

$$W = \frac{t^2 R}{.0795\ (d + t + 0.85y)}$$

It is often more convenient to use $(O.D. - t)$ instead of $(d + t)$.

p and w are any combination of internal pressure and external load which will just cause fracture. In the design of pipe thickness, p and w are quantities obtained by multiplying the internal water pressure and the earth load, each as determined by the condition under which the pipe is assumed to be used, by the desired factor of safety.

Sect. 1-5. Ratios to Three-Edge Bearing

As noted in Sections 1–3 and 1–4 the parabola described in those sections is for a pipe to which the exterior load and support are applied as in 3-edge bearing. This does not represent any field condition but is used as a convenient medium of computing for the field conditions, A, B, C, D, E and F, previously described. The factor or "ratio to 3-edge bearing" by which the trench load acting in each of these field conditions A to F must be divided so that the load thus altered will have *the same effect on a pipe subjected to 3-edge bearing as the actual load does on the pipe subjected to the given field condition*, has been determined with sufficient accuracy for design purposes and is shown in Fig. 3. In general terms it will be seen that all field conditions except C (blocks with no tamping) and D (blocks with tamping) are more favorable than 3-edge bearing in that the loads are to be divided by a ratio larger than unity.

Pipes laid on blocks, as in Field Conditions C and D, particularly C in which the fill is untamped, have the most unfavorable ratios. The ratios in these cases are less definite than for Field Conditions A, B, E and F because they are affected greatly by firmness of foundation under the blocks, firmness of tamping, size of blocks and hardness of the wood, and presence or absence of wedges which, when substantial, aid the strength by forming haunch supports. Values of the C ratio shown on Fig. 3 are for a rather severe condition and those for the D ratio an ordinary or average condition. In either case blocks are assumed to be spaced 6 feet apart on the average, i.e. two blocks per 12-foot length and a correspondingly greater number for longer lengths of pipe. *Greater average spacing will give more severe conditions to which the ratios are not applicable.*

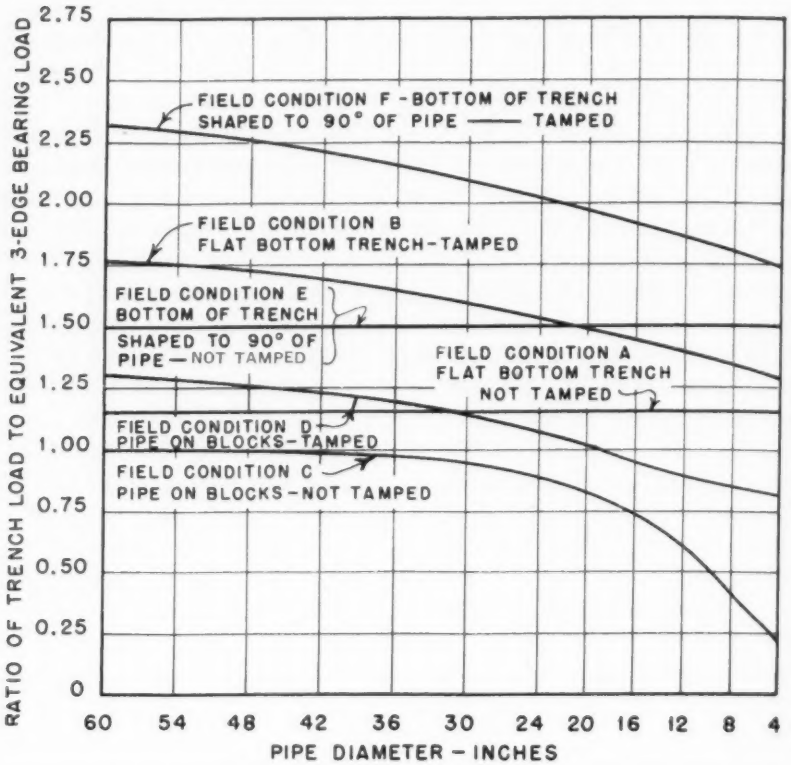
See Section 1–13 for the effect of beam action on thickness of smaller pipes spanning between blocks in Field Condition C.

Sect. 1-6. Forces Acting on Pipe When in Service

Cast iron or other pipe laid in the ground are acted on by one or more of the following forces:

1. Internal static pressure of the liquid or gas which is contained in the pipe.

2. Water hammer (or hammer from other liquid).
3. Load from the backfill.
4. Load and impact from passing trucks or other vehicles.



SIZE	4″	6″	8″	10″	12″	14″	16″	18″	20″	24″	30″	36″	42″	48″	54″	60″
A	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
B	1.29	1.32	1.34	1.36	1.38	1.41	1.43	1.45	1.47	1.52	1.58	1.64	1.69	1.72	1.75	1.77
C	.22	.31	.40	.50	.60	.67	.73	.78	.81	.87	.93	.96	.98	.99	.99	1.00
D	.82	.83	.84	.86	.88	.91	.95	.98	1.01	1.07	1.14	1.19	1.23	1.25	1.28	1.31
E	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
F	1.75	1.78	1.80	1.83	1.85	1.88	1.90	1.93	1.95	2.00	2.08	2.14	2.20	2.25	2.29	2.31

Note: C and D ratios are for an average block spacing of 6 feet.

FIG. 3. Ratios to 3-edge Bearing

Loads 2 and 4 are occasional and transitory. In the specifications of Committee A21 they are not assumed as acting simultaneously but both are considered separately as loads added to static pressure and backfill load, and whichever of the two gives the greater computed

thickness of pipe, when taken together with the normal loads 1 and 3, is controlling in the determination of pipe thickness for the case under consideration.

Pipe for gas are free from the hammer caused by liquids and are hence always computed with truck load and its impact added to to the load from backfill.

Definite values of the above loads, obtained as explained in Sections 1–7, 1–8 and 1–9, are used in the parabolic curve, generally graphically, to obtain the computed pipe thicknesses.

Sect. 1-7. Water Pressure and Water Hammer

The static pressure will of course be known or assumed from conditions fixed by the pipe line design. The intensities of water hammer vary greatly according to types of gate valves, check valves and altitude valves; types of pump and power; presence or absence of automatic relief valves with effective quick acting controls; arrangement of pipe line, i.e., whether single or part of a grillage system; and other factors which it would require too much space to enumerate. Experiments on water hammer under the various usual conditions in which water pipe are used are few and Committee A21 has been unable from its inquiries to suggest improvements over the assumptions of water hammer made by the late Dexter Brackett, which have therefore been used in computing the thickness tables. They are listed in Table 1. *Each designer of a pipe line should consider whether the conditions in his case may need a more liberal water hammer allowance.*

TABLE 1

Allowances for Water Hammer

DIAM. OF PIPE, INCHES	WATER HAMMER, LB. PER SQ.IN.	DIAM. OF PIPE, INCHES	WATER HAMMER, LB. PER SQ.IN.
4 to 10	120	24	85
12 to 14	110	30	80
16 to 18	100	36	75
20	90	42 to 60	70

Sect. 1-8. Estimation of Earth Loads

Earth loads are computed by mathematical formulae developed at Iowa State College and based on full scale tests extending over a period of more than 25 years. The growth of this system of earth load estimation is to be found in Bulletins 31, 36, 47, 57, 76, 80, 96,

104, 108, 112 of the Engineering Experiment Station at Iowa State College. Simplified statements may be found in a paper by Wiggin, Enger and Schlick given before the American Water Works Association in April, 1938 (Jour. A. W. W. A., **31**: 841 (1939)) and in one by W. D. Moore before the American Water Works Association in June, 1939 (Jour. A. W. W. A., **31**: 1655 (1939)).

On account of the mathematical work involved in computing these loads, Committee A21 arranged with Professor Schlick to make or supervise the necessary computations of earth loads under several

TABLE 2

List of Fill-Load Diagrams

FIG. NO.	TRENCH		WEIGHT OF EARTH, LB. PER CU. FT.	FIELD CONDITIONS OF LAYING TO WHICH APPLICABLE
	Width	Slope of Sides		
4	d + 2 ft.	Vertical	120	A, B, C, E and F
5	d + 2 ft.	Vertical	120	D
6	d + 1 ft.	Vertical	120	A, B, C, D, E and F
7	See Diagram	1 on 1	110	A, B, C, D, E and F
8	See Diagram	2 on 1	120	A, B, C, D, E and F

Note 1. d is nominal diameter of pipe expressed in feet.

Note 2. Figures 4, 6, 7 and 8 are applicable to all field conditions, except D, by direct use of the curves. Figure 5 gives earth loads for Field Condition D with d + 2 ft. trench. For the d + 1 ft. trench and the sloping-sided trenches loads for Field Condition D are found by reading from the diagrams and applying the percentages given on the diagrams for condition D.

Note 3. This Manual does not include fill-load diagrams and tables of 3-edge bearing ratios for conditions produced when an embankment is placed over a pipe which is laid wholly or partly projecting from the base on which the embankment is subsequently deposited.

different conditions of trench width, slopes of sides of trench, methods of supporting the pipe and depths of cover. These computations have been used in preparing the diagrams listed in Table 2. Copies of these diagrams follow in this Manual.

The earth loads used in computing the thickness tables in Committee A21 work are shown on diagrams, Figures 4 and 5, listed in Table 2, i.e., for vertical-sided trench 2 feet wider than the nominal diameter of the pipe. Figures 6, 7 and 8 give fill-loads for use in design for three types of trench different from those assumed in computing the pipe thickness tables.

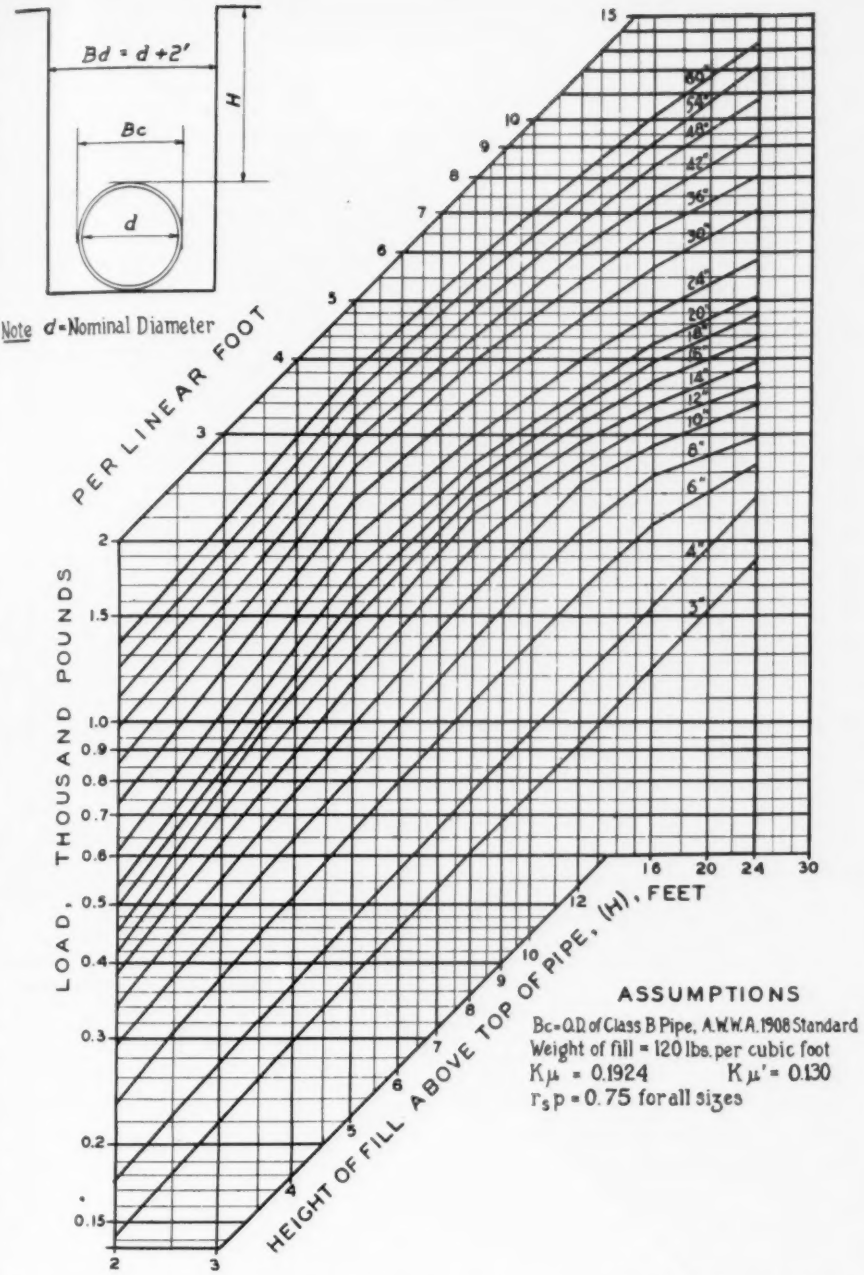


FIG. 4. Fill Loads on Pipe for Width of Ditch d + 2 feet and Field Conditions A, B, C, E, and F

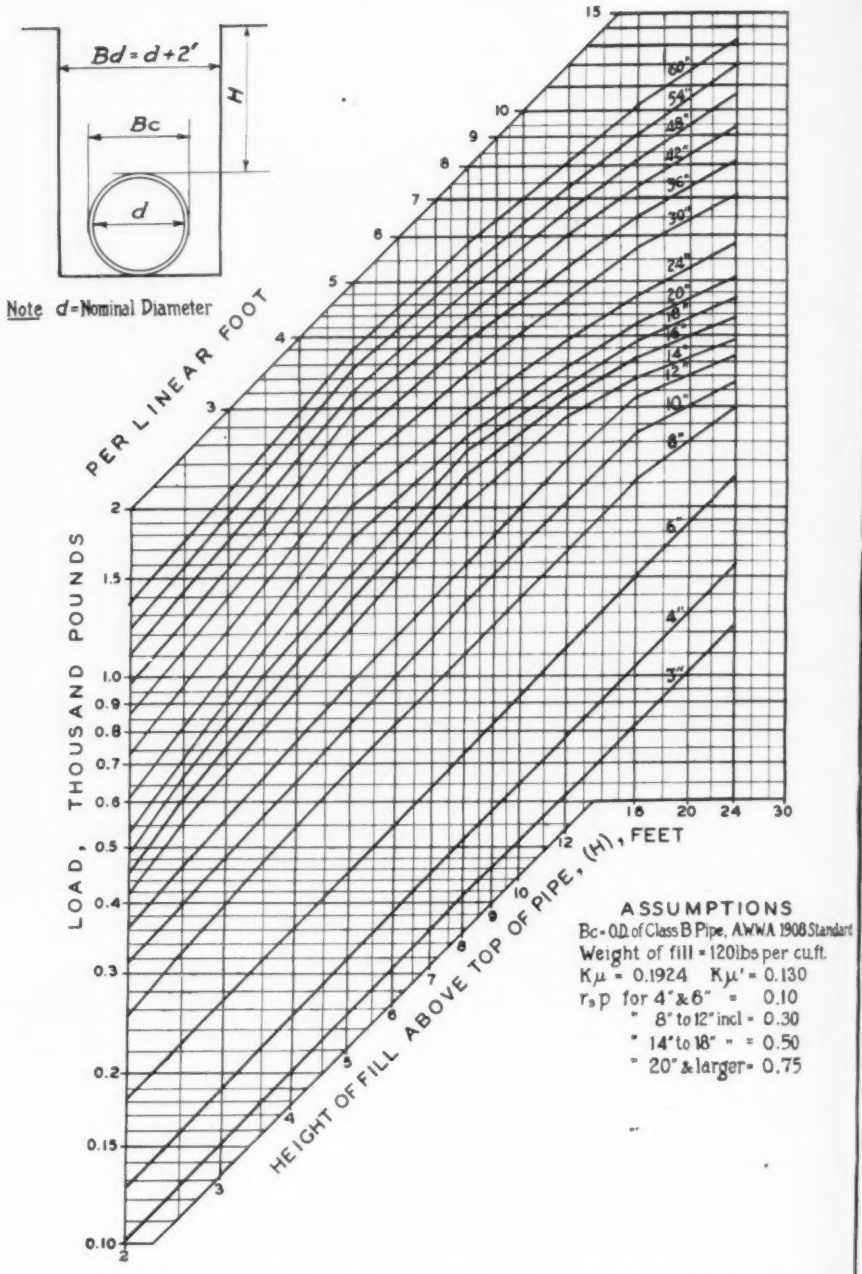
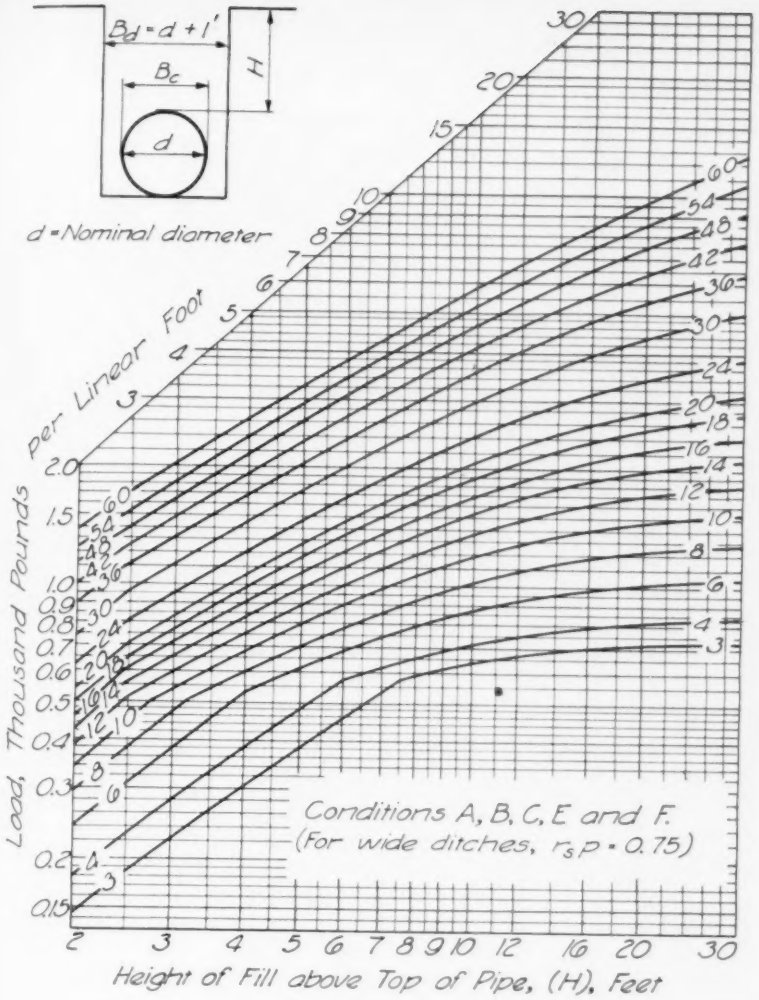


FIG. 5. Fill Loads on Pipe for Width of Ditch d + 2 feet and Field Conditions D

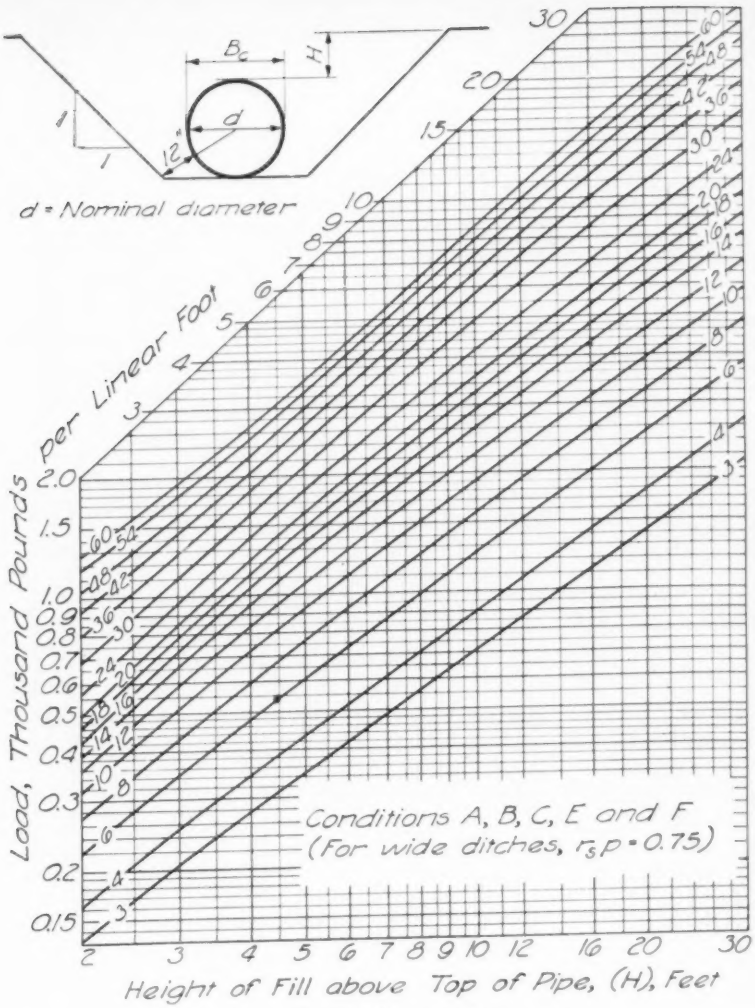


Condition D

Size of pipe, inches	$r_s p$ for wide ditches	Percent of diagram load				
		Values of H, feet				
		2	5	10	18	30
3 to 6	0.10	70	70	95	100	100
8 to 12	0.30	90	100	100	100	100
14 to 18	0.50	100	100	100	100	100
20 & more	0.75	100	100	100	100	100

Fill Loads - Vertical Sided Ditch of Width $d + 1'$
For B_c = O.D. of Class B, A.W.W.A. 1908 Standards
W = unit weight of fill = 120 lb. per cu. ft.
$K\mu = 0.1924$ $K\mu' = 0.130$

FIG. 6. Fill Loads on Pipe for Width of Ditch d + 1 ft.



Condition D

Size of pipe, inches	$r_s p$ for wide ditches	Percent of diagram load — Values of H, feet				
		2	5	10	18	30
3 to 6	0.10	70	70	70	65	65
8 to 12	0.30	90	85	80	80	80
14 to 18	0.50	100	95	90	90	90
20 & more	0.75	100	100	100	100	100

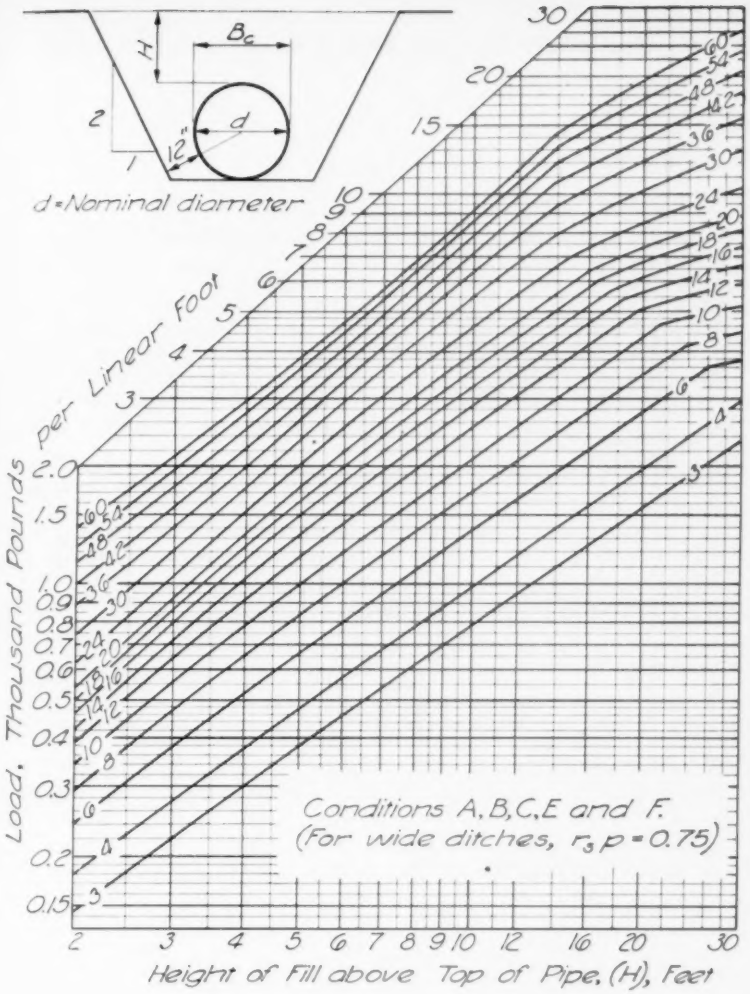
Fill Loads - Ditch with Sides Sloping 1 on 1

For B_c = O.D of Class B, A.W.W.A. 1908 Standards

W = unit weight of fill = 110 lb. per cu. ft.

$K\mu = 0.1924$ $K\mu' = 0.150$

FIG. 7. Fill Loads on Pipe for Ditches Having 1 on 1 Side Slopes



Condition D

Size of pipe, inches	$r_s p$ for wide ditches	Percent of diagram load				
		Values of H, feet				
		2	5	10	18	30
3 to 6	0.10	70	70	70	70	70
8 to 12	0.30	95	85	80	80	100
14 to 18	0.50	100	95	90	95	100
20 & more	0.75	100	100	100	100	100

Fill Loads - Ditch with Sides Sloping 2 on 1

For B_c = O.D. of Class B, A.W.W.A. 1908 Standards

W = unit weight of fill = 120 lb. per cu. ft.

$K\mu = 0.1924$ $K\mu' = 0.130$

FIG. 8. Fill Loads on Pipe for Ditches Having 2 on 1 Side Slopes

Sect. 1-9. Truck Superload and Impact

In computing pipe thicknesses, truck loads are added to earth loads in certain cases (see Sections 1–6 and 1–11, Sub-section (f)). Two passing trucks are assumed with rear axles both over the pipe at the same time, adjacent wheels of the two trucks 3 feet apart

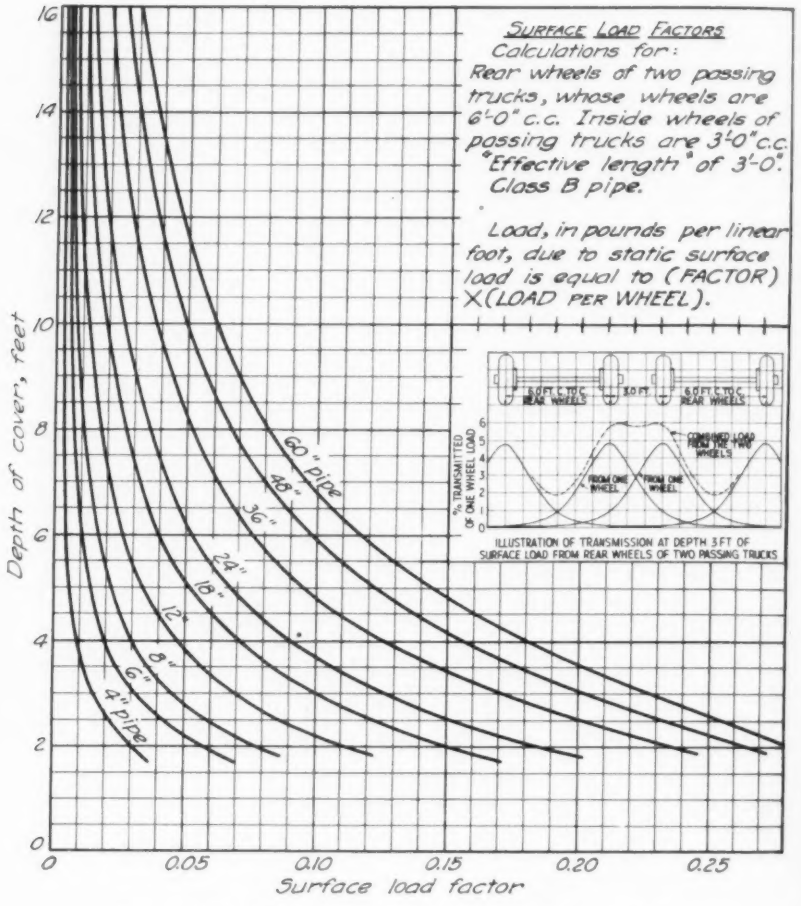


FIG. 9. Surface Load Factors for Two Passing Trucks

center to center, and load on each rear wheel 9,000 lb. To the load thus obtained 50 per cent is added for impact of the moving trucks over a road or trench surface assumed to be rough.

The proportion of a wheel load which is transmitted through the backfill to the pipe itself (the remainder being spread on either side

of the pipe) diminishes as depth of cover increases, and the length of pipe, over which the load which comes on the pipe is spread, increases with increase in depth of cover. These effects have been determined quantitatively by experiment at Iowa State College over a period of years and the results have been plotted by Prof. W. J. Schlick of that college for use of Committee A21. Figure 9 shows Prof. Schlick's diagram from which may be read the factors varying with size of pipe and depth of cover by which to multiply a single truck wheel load in order to give the average load per foot on the pipe from the two adjacent truck wheels placed three feet center to center along the pipe as above described.

On this diagram, Fig. 9, is a small sketch illustrating the distribution of this truck load along the pipe. In designing the pipe there

TABLE 3

DIAMETER OF PIPE, INCHES	PERCENTAGES OF TRUCK LOAD USED							
	2.5′–3.5′ Cover Field Cond.		4′–7′ Cover Field Cond.		8′–10′ Cover Field Cond.		Over 10′ Cover Field Cond.	
	A, B, E & F	C & D	A, B, E & F	C & D	A, B, E & F	C & D	A, B, E & F	C & D
4 to 12	100	78	100	84	100	90	100	95
14	92	78	100	84	100	90	100	95
16	88	78	95	84	100	90	100	95
18	85	78	90	84	100	90	100	95
20	83	78	90	84	95	90	100	95
24 to 30	81	78	85	84	95	90	100	95
36 to 60	80	78	85	84	90	90	100	95

are reductions to be made in the truck loads determined as above described. With field conditions C and D, in each of which the pipe is supported on blocks, the truck load, which is of intensity indicated by the diagram only over a few feet of the pipe, gives less load on the blocks than if the truck load were continuous over at least two lengths of the pipe. Similarly with field conditions A, B, E, and F the parts of the pipe which receive the truck load in its full intensity are aided in carrying the load by adjacent parts of the pipe which receive less load or no load from the trucks. These effects have been studied in detail by the Committee and the ameliorating effects estimated as given in Table 3.

The use of Table 3 is illustrated in the examples of actual design of pipe given in Section 1–11, Sub-section (g).

Sect. 1-10. The Factors of Safety

The factors of safety assumed by Committee A21 in computing pipe thicknesses are as follows:

For external loads.....2.5
For internal pressure....2.5

These factors of safety are necessarily chosen arbitrarily. They are considerably lower than the factor of safety which was formerly thought to exist for cast iron pipe but that was when only water pressure and water hammer were considered. The factors of safety were chosen of a magnitude which would result in thicknesses for pipe under ordinary conditions of use, which have been found satisfactory under those conditions, considering both American and foreign experience but giving more weight to American experience. The foreign standards are generally thinner than American standards for the same service.

It will be seen in Sect. 1–12 that the factor of safety is in effect generally made higher for pipe 8 inches and less in diameter for ordinary pressures and depths of cover, because their computed thicknesses are smaller than experience shows to be safe for handling, so that greater thicknesses are used arbitrarily.

Sect. 1-11. Details of Applying Method of Computing Net Barrel Thickness, with Illustrations

(a) *Net Thickness Defined; Additions to Net Thickness for Foundry Tolerance and Corrosion.* Section 1–11 relates especially to computation of *net thickness.* Net thickness is assumed in this Manual to mean the thickness available for resisting the external loads and internal pressures to which the pipe may be subjected. The net thicknesses computed in accordance with the following sub-sections are to be increased by the additions below noted in order to obtain the total or gross thickness.

(1) Foundry tolerance permitted below standard thickness.
(2) Corrosion allowance.

These additions to thickness, being different in total magnitude for pipes manufactured by different methods, are treated in detail in subsequent parts of the Manual which are devoted each to a separate type or group of types of pipe; e.g., see Part 2 for Cast Iron Pit Cast Pipe.

(b) *Equation Used and Data Required.* In computing net barrel thicknesses of cast iron pipe the equation for the load-pressure

parabola explained in Sect. 1–4 is used. This equation in convenient form for use is

$$w = \frac{W}{\sqrt{P}} \sqrt{P - p}, \text{ where}$$

w, W, p & P have the significance explained in Sect. 1–4.

The problem is generally as follows:
Given:

(1) Nominal diameter of pipe, d, inches
(2) Assumed width of trench
(3) Cover, or depth of fill over pipe
(4) Assumed Field Condition, i e. A, B, C, D, E or F.
(5) Maximum static pressure expected to occur in service, lb. per sq.in.
(6) Assumed magnitude of water hammer, lb. per sq.in.
(7) Assumed strength of iron in bursting pipe, S, lb. per sq.in.
(8) Assumed strength of iron in crushing of pipe as a ring, R, lb. per sq.in.
(9) Factor of safety.

Required: to find the necessary thickness of the pipe.

(c) *Graphical Method Described.* The easiest approach to the problem is to assume two or three different net thicknesses, varying by $\frac{1}{16}$ inch, covering the range within which the thickness to be determined is expected to lie. Plot the load-pressure curves for each of these thicknesses on the same diagram, using the same co-ordinate axes. Then plot a single point on the same diagram with the p and w (see Sect. 1–3, Fig. 1) for the given conditions as co-ordinates. The thickness is obtained by interpolation. Figures 10, 11, and 12 illustrate three methods of making such diagrams.

(d) *First Graphical Method—Load Pressure Parabolas Plotted to Natural Scale (Fig. 10).* The first method, shown on Fig. 10, is to draw the load-pressure parabolas to natural scale. They can be drawn when the values of P and W for each assumed thickness have been computed in the manner explained in Sect. 1–4, P being the abscissa of the vertex of the parabola and W being the ordinate with abscissa zero. The remainder of each parabola is located by plotting back from a vertical line through the vertex of the parabola three intermediate points with the fractional abscissae $\frac{1}{16}$ P, $\frac{4}{16}$ P, and $\frac{9}{16}$ P, the corresponding ordinates being $\frac{1}{4}$ W, $\frac{1}{2}$ W, and $\frac{3}{4}$ W respectively. If preferred, the intermediate points may be obtained

from the equation of the parabola, assuming values of p in round numbers and computing the corresponding values of w.

(e) *Second Graphical Method—Load-Pressure Parabolas Plotted as Straight Lines* (*Fig. 11*). The second method of plotting, shown in Fig. 11, is by use of a special scale of ordinates in which the plotted length of each ordinate is the square of the actual length. This

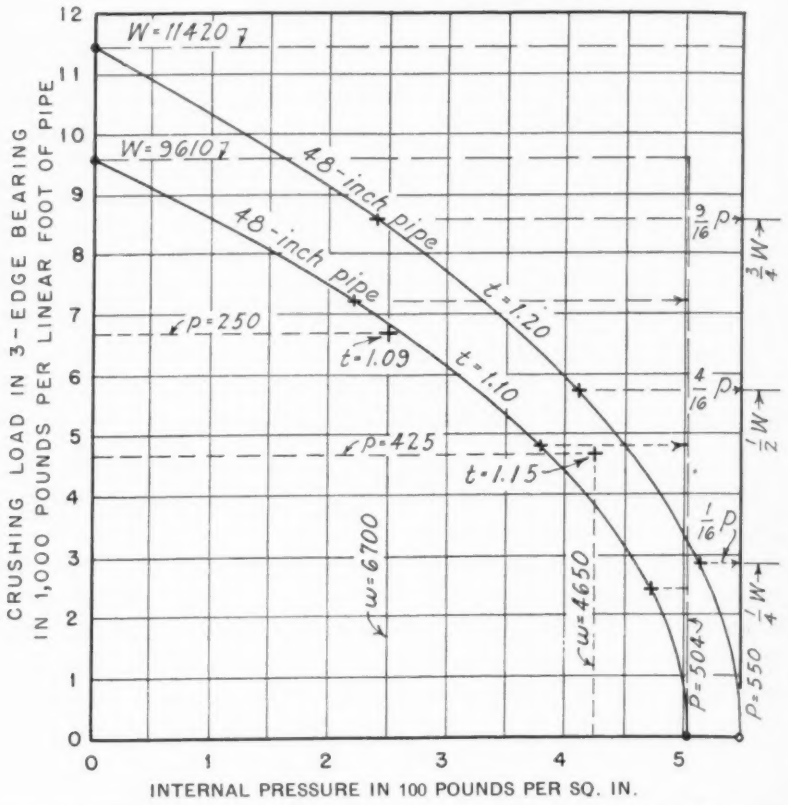


FIG. 10. Determining Thickness of Cast Iron Pipe by Parabolic Load-Pressure Curves Drawn to Natural Scale; 48-inch Pipe Used as Sample

makes the parabolas plot as straight lines which can be drawn at once when the values of P and W are known for each parabola. Standard forms like Fig. 11 were used extensively in thickness computations for Committee A21 and are applicable in the solution of any problem with any assumptions as to unit strengths of iron (S and R) or other conditions. For computation of the many cases required for tables of thickness with constant values of S and R,

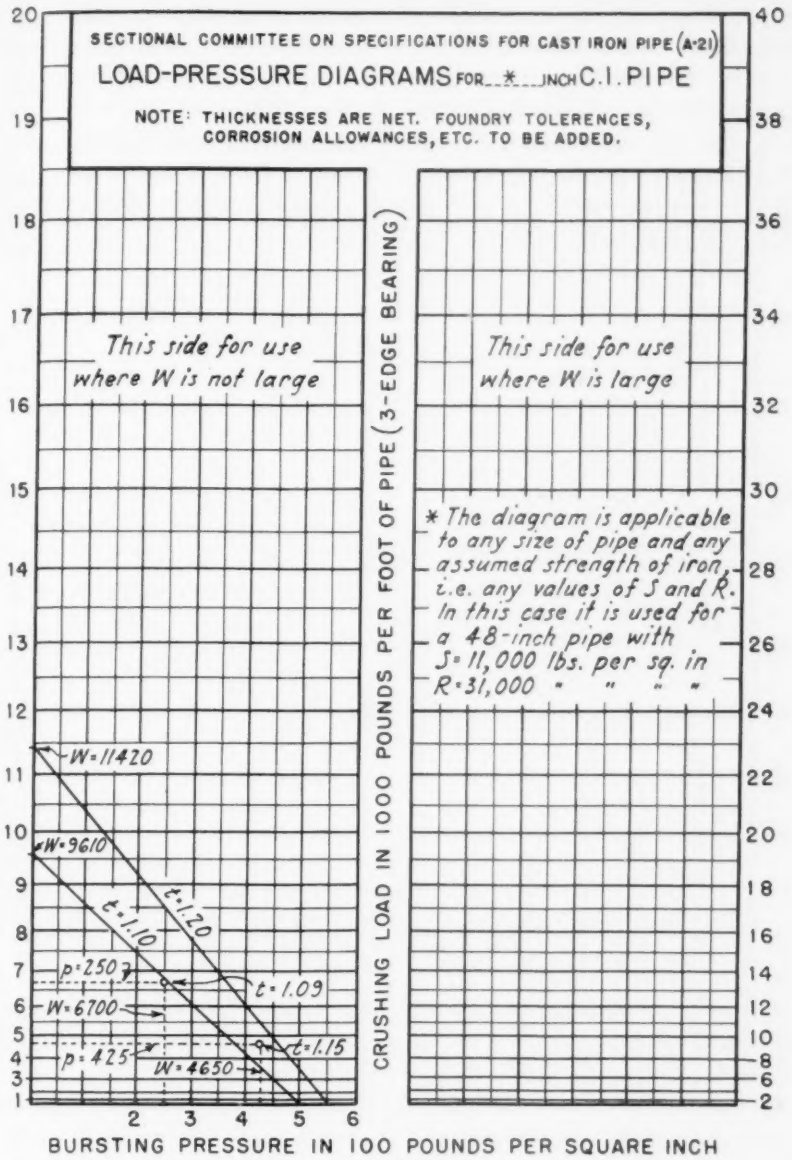


FIG. 11. Determining Thickness of Cast Iron Pipe by Load-Pressure Parabolas Drawn as Straight Lines; 48-inch Pipe Used as Sample

the method shown in Fig. 12, explained below, is much more expeditious and was used in the final tables of thicknesses submitted by Committee A21.

(f) *Third Graphical Method—Nomogram (Fig. 12).* In this third graphical method shown in Fig. 12, definite thickness points are plotted between which the desired thickness may be obtained by interpolation. As in Fig. 11, the external load scale (at left in Fig. 12) is one in which the vertical distance from zero is plotted as a height equal to the *square* of the exterior load which is actually marked on the scale. The internal pressure scale (at the right in Fig. 12) is a natural scale.

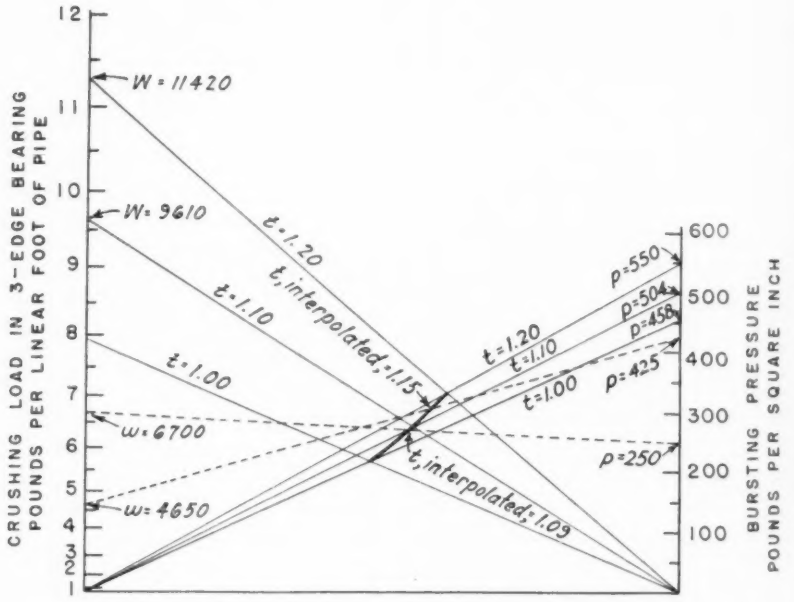


FIG. 12. Determining Thickness of Cast Iron Pipe by Nomogram Method; 48-inch Pipe Used as Sample

Such a diagram, in blank, with the exterior load and the interior pressure scale constructed as above described, may be used, as may Fig. 11, to plot any two or more thicknesses (computed with any specified values of S and R) between which to interpolate for solving any problem in barrel thickness computation by the Committee A21 method. The particular diagram or nomogram shown as Fig. 12 shows merely three definite thickness points between which interpolation for a single problem has been made but Figures 2.1, 2.2 and 2.3 in Appendix 2 show thickness points covering a wide range of thicknesses for pipes from 3 inches to 60 inches in diameter, for iron having $S = 11{,}000$ and $R = 31{,}000$ pounds per square inch.

This type of nomogram, devised by C. K. Donoho of the American Cast Iron Pipe Company, is the best method yet known for general use. With a group of such nomograms for each desired pair of corresponding values for S and R any net thickness may be read by a single application of a straight edge between known points p and w which have been determined for the particular problem.

(g) *A concrete example* is worked out below by each of the three methods.

The Example:

Nominal diameter of pipe	48 inches
Trench width	$d + 2' = 6$ ft.
Cover	5 ft.
Method of laying	Field Condition B
Static pressure	100 lb. per sq.in.
Water hammer—as in Sect. 1–7	70 lb. per sq.in.
Strength of iron in bursting pipe	$S = 11{,}000$ lb. per sq.in.
Strength of iron in crushing of pipe as a ring	$R = 31{,}000$ lb. per sq.in.
Factor of safety	2.5

To find required net barrel thickness.

Solution:

Fill load per lin. ft. of pipe, (Fig. 4)		3,200 lb.
Truck load (Fig. 9), $0.1225 \times 9000 = 1100$		
Add for impact $50\% =$	550	
	1650	
Percent. of Truck Load used (Table in Sect. 1–9) 85% of 1650	=	1,400
Fill load plus truck load		4,600

Since the load-pressure curve is applicable only when exterior loads are transformed to loads in 3-edge bearing (see 1–5 and Fig. 3) the fill load of 3200 and the fill load plus truck load are to be reduced by dividing by the 3-edge ratio for 48-inch pipe with B condition of loading. This ratio is 1.72 (see Fig. 3).

3-edge bearing load equivalent to fill-load = $3200/1.72 = 1860$

3-edge bearing load equivalent to fill load + truck load = $4600/1.72 = 2680$

Case 1. Water Hammer Assumed but No Truck Load.

The pipe is to be designed so that it will just break when subjected simultaneously to:

p = (static pressure plus water hammer) $\times$ factor of safety 2.5 and

w = (3-edge bearing load equivalent to fill load) $\times$ factor of safety 2.5

In this case: $p = (100 + 70) \times 2.5 = 425$

$w = 1860 \times 2.5 = 4650$

Case 2. Truck Load Assumed but no Water Hammer.

The pipe is to be designed so that it will just break when subjected simultaneously to:

p = static pressure $\times$ factor of safety 2.5

w = (3-edge bearing load equivalent to fill load plus truck load) multiplied by factor of safety 2.5

In this case: $p = 100 \times 2.5 = 250$

$w = 2680 \times 2.5 = 6700$

The values of p and w in Cases 1 and 2 are to be plotted on diagrams to be constructed by the three methods described in subsections (d), (e), and (f) above. Two arbitrary pipe thicknesses will be assumed in making these diagrams, viz. 1.10 and 1.20.

For $t = 1.10$:

$$P = \frac{2tS}{d} \text{ (Sect. M4)} = \frac{2 \times 1.10 \times 11000}{48} = 504$$

$$W = \frac{t^2R}{.0795\,(d + t)} \text{ (Sect. M4)} = \frac{(1.10)^2 \times 31{,}000}{.0795 \times 49.1} = 9{,}610$$

For $t = 1.20$:

$$P = \frac{2 \times 1.20 \times 11000}{48} = \ldots\ldots\ldots\ldots\ldots\ldots \quad 550$$

$$W = \frac{(1.20)^2 \times 31{,}000}{.0795 \times 49.2} = \ldots\ldots\ldots\ldots\ldots\ldots \quad 11{,}420$$

With the above values of P and W the parabolas for $t = 1.10$ and $t = 1.20$, respectively, are plotted as curves on Fig. 10 and as straight lines on Fig. 11. On Fig. 12 the two definite thickness points, viz. for $t = 1.10$ and $t = 1.20$, are plotted by the intersection

of two lines as shown, and in order to make the shape of the thickness curve for the 48-inch pipe more evident, a third point has been added for $t = 1.00$ with P and W 458 and 7960 respectively, computed in the same manner as shown previously for $t = 1.10$ and $t = 1.20$.

Interpolations are made on each of the three diagrams by using values of p and w for Case 1 and Case 2 computed above on page 22. The same results are seen to be obtained from all three diagrams and are as follows:

For Case 1, assuming water hammer but no truck load, the plotted point falls about half way between the load-pressure lines for $t = 1.10$ and $t = 1.20$, and by this interpolation ..... $t = 1.15$

For Case 2, assuming truck load but no water hammer, the plotted point falls just below the load-pressure line for $t = 1.10$, giving ..... $t = 1.09$

The nomogram, Fig. 12, gives the same results.

The water hammer assumption is hence controlling and the net design thickness is ..... $t = 1.15$

For a gas pipe, where water hammer is absent, Case 2 only would be computed and the net thickness would be ..... $t = 1.09$

(h) *Net Thickness Increased by Foundry Tolerance and Corrosion Allowance.* To each of the net thicknesses computed in Sub-section (g) above, are to be added foundry tolerance and corrosion allowance, which, for 48-inch pit cast pipe, have been assumed by Committee A21 as .10 and .08 inch respectively. These additions will make the thicknesses as follows:

For water pipe, $1.15 + .10 + .08 = 1.33$
For gas pipe, $1.09 + .10 + .08 = 1.27$

By reference to the Manual, Part 2, Appendix 2A, table 2A.2, page 17, it will be noted that the calculated thickness of a 48-inch water pipe for 100 lb. pressure and 5 foot cover is 1.33, though, as explained in Part 2, the standard thickness is made 1.37 which is the nearest standard thickness class. The standard thickness class for the above gas pipe is 1.27.

Sect. 1-12. Arbitrary Minimum Thickness, when Greater than Computed Thickness, Used Instead of Computed Thickness

Irrespective of calculated thickness, no standard thickness is made less than a certain minimum thickness for the particular diameter and kind of iron. This minimum thickness is chosen by judgment with due regard to shocks received by the pipe in handling and transporting. This provision controls thicknesses of 3-inch and 4-inch pipe for most pressures and covers, controls thicknesses of 6-inch and 8-inch under most of the ordinary conditions of pressure and cover, and controls thicknesses of 12-inch and 14-inch pipe under a few of the lighter pressures and covers.

As these minimum thicknesses vary for pipe made by different processes, they are treated in detail for each kind of pipe in the appropriate part of the Manual, e.g., Pit Cast Pipe in Part 2.

Sect. 1-13. Beam Conditions Control Thicknesses of Smaller Pipe with Field Condition C unless Blocks are Favorably Spaced

A pipe supported on blocks with untamped backfill acts as a beam spanning between the blocks to a greater or less extent depending on the hardness of the foundation under the blocks, the size and hardness of the blocks themselves, also the stiffness of the pipe as a beam and the degree to which some supporting fill happens to run under the pipe between blocks. The only safe assumption is to assume conditions giving unreduced beam action. For the smaller pipe, 3-inch to 8-inch inclusive, it has been found necessary to investigate the pipe as beams. Wherever the thickness of the pipe computed as a beam, using the net thickness as defined in Sect. 1–11, Sub-sect. (a), is greater than that determined by the methods described in Sect. 1–11 and 1–12, the beam thickness is used.

Spacing of blocks affects greatly the stresses caused by beam action. The most favorable location for two blocks under a 12-foot length of pipe is approximately 30-inches from each end of the pipe. With such a spacing, the 3-inch size is the only one (of those included in the thickness tables) in which the thicknesses are affected by beam conditions and then only with earth covers over about 10-feet. For other spacing of blocks, thicknesses of 4-inch, 6-inch and 8-inch pipe may be affected. Tables 2A.3 and 2B.3 in Appendices 2A and 2B, in Part 2 of the Manual, show these effects in detail for pit cast pipe. Corresponding tables for other types of pipe will show similar data for such types of pipe.

Sect. 1-14. To Compute Factor of Safety of a Given Pipe

The formula for load-pressure relationship can be used to compute factors of safety when thickness of pipe is known. Two examples are given below.

Example 1

For convenience in checking results, the same example, a 48-inch pit cast pipe, that was used in Sect. 1–11 to illustrate methods of computing barrel thickness, will be reversed by using the thickness therein computed (see Sect. 1–11, Sub-sect. (g), and finding its factor of safety. Case 1, assuming water hammer and no truck load, will be used. Field Condition B will be assumed as before.

The necessary thickness to order from the foundry was computed as 1.33. If the particular length were of minimum thickness permitted under the specifications, 1.23, and had further corroded so as to have a loss in strength equal to that which would be produced by making it 0.08 inch thinner, its net thickness would be 1.15.

For a 48-inch pit cast pipe of thickness 1.15, made of iron having $S = 11{,}000$ and $R = 31{,}000$,

$$P = \frac{2tS}{d} = \frac{2 \times 1.15 \times 11{,}000}{48} = 527 \text{ lb. per sq.in.}$$

$$W = \frac{t^2R}{.0795\,(d + t)} = \frac{(1.15)^2 \times 31{,}000}{.0795 \times 49.15} = 10{,}490 \text{ lb.}$$

The formula for the load-pressure curve is:

$$w = \frac{W}{\sqrt{P}}\sqrt{P - p}$$

In this case W and P have the values computed above, and, if we call the unknown factor of safety x, w has the value $1860x$ (see page 21 for the 1860) and p has the value $170x$ (see page 22 for 170).

The factor of safety is found algebraically as shown below. By substituting the above values in the above formula the equation becomes:

$$\begin{aligned}
1860x &= \frac{10490}{\sqrt{527}}\sqrt{527 - 170x} \\
1860x &= 457.5\sqrt{527 - 170x} \\
x &= .246\sqrt{527 - 170x} \\
x^2 &= .0605\,(527 - 170x) \\
x^2 &= 31.9 - 10.3x \\
x &= -5.15 + \sqrt{31.9 + (5.15)^2} \\
x &= -5.15 + \sqrt{58.4} = -5.15 + 7.64 \\
x &= 2.49
\end{aligned}$$

Since the factor of safety used in the original example was 2.5, a good check is afforded by the 2.49 obtained above.

Example 2

This example is to find what factor of safety the same 48-inch pipe with net thickness of 1.15 would have, assuming the same loading and internal pressure, if it were laid on blocks with untamped backfill.

By reference to Fig. 3, the ratio to 3-edge bearing is found to be 0.99. The 3-edge bearing load equivalent to the fill load will be:

$3200/.99 = 3230$, instead of:

$3200/1.72 = 1860$, as in the previous example.

All other values in the formula remain as in Example 1 above and the equation becomes:

$$
\begin{aligned}
3230x &= \frac{10490}{\sqrt{527}}\sqrt{527 - 170x} \\
3230x &= 457.5\sqrt{527 - 170x} \\
x &= .1413\sqrt{527 - 170x} \\
x^2 &= .0200\,(527 - 170x) \\
x^2 &= 10.54 - 3.40x \\
x &= -1.70 + \sqrt{10.54 + (1.7)^2} \\
x &= -1.70 + \sqrt{13.43} = -1.70 + 3.66 \\
x &= 1.96
\end{aligned}
$$

That is, the factor of safety in this case is reduced from 2.5 to 1.96 by using blocks with untamped backfill instead of flat bottomed trench, with tamped backfill.

MANUAL FOR THE COMPUTATION OF STRENGTH AND THICKNESS OF CAST IRON PIPE

PART 2

with

Comprehensive Tables

Of Calculated and Standard Barrel Thicknesses

For Pit Cast Pipe for Water or Other Liquids

All Computations Based on: S=11,000 lb. per sq.in. and R=31,000 lb. per sq.in.

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MANUAL

Part 2

Cast Iron Pit Cast Pipe

Sect. 2A-1. Introductory Statement; Unit Strength of Iron

Calculated thicknesses given in the comprehensive tables in Appendices 2A and 2B are computed by the method described in the Manual Part 1, using unit strengths of pit cast pipe iron which comply with the specifications for Cast Iron Pit Cast Pipe for Water or Other Liquids and with the specifications for Cast Iron Pit Cast Pipe for Gas. These unit strengths are as follows:

S, Bursting Strength, = 11,000 lb. per sq.in.
R, Crushing Strength, = 31,000 lb. per sq.in.

Figures 2.1, 2.2 and 2.3 are the nomograms by use of which the necessary net thickness may be determined for any pipe from 3-inch to 60-inch inclusive, made of 11000–31000 cast iron, and, within the limits of the diagrams, for any internal pressure and any exterior equivalent 3-edge load. The use of these nomograms is described in the Manual, Part 1, Section 1–11, Sub-sections (f) and (g) and Fig. 12. The three nomograms, Figures 2.1, 2.2 and 2.3, with varying scales, are needed to cover the full range of conditions. One diagram, made to sufficiently large scale to permit reading the smaller loads, would be very large because of the fact that the squares of the loads are plotted.

Sect. 2A-2. Additions to Net Computed Thicknesses to Obtain Calculated Thicknesses

Calculated thicknesses are obtained by adding to net thickness computed by the parabolic formula the following constants:

(a) Maximum foundry tolerances permitted by the specifications;
(b) Corrosion allowance of .08 inch.

Maximum foundry tolerances are as follows:

Diameters Inches	Maximum Foundry Tolerances Inches
3 to 8 inclusive	.07
10 to 24 inclusive	.08
30 to 60 inclusive	.10

Sect. 2A-3. Minimum Thicknesses of Pipe

Irrespective of calculated thicknesses no standard thickness is made less than the minima shown in Table 2.1, chosen by judgment with due regard to shocks received by the pipe in handling and transporting.

Sect. 2A-4. Standard Thickness Classes

Calculated thicknesses are not used exactly but the Standard Thickness Class, from the Table 2.2, nearest to the calculated thickness (or the next thicker standard thickness class in case the calculated thickness is halfway between two standard thicknesses) is used in order to avoid an endless number of different thicknesses varying by small intervals.

TABLE 2.1

Minimum Thicknesses for Cast Iron Pit Cast Pipe

DIAMETER OF PIPE, INCHES	MINIMUM THICKNESS, INCHES
3	.37
4	.40
6	.43
8	.46
10	.50
12	.54
Larger than 12	As computed for 50 lb. static pressure plus water hammer, with trench load for cover of 5 feet and Field Condition B.**

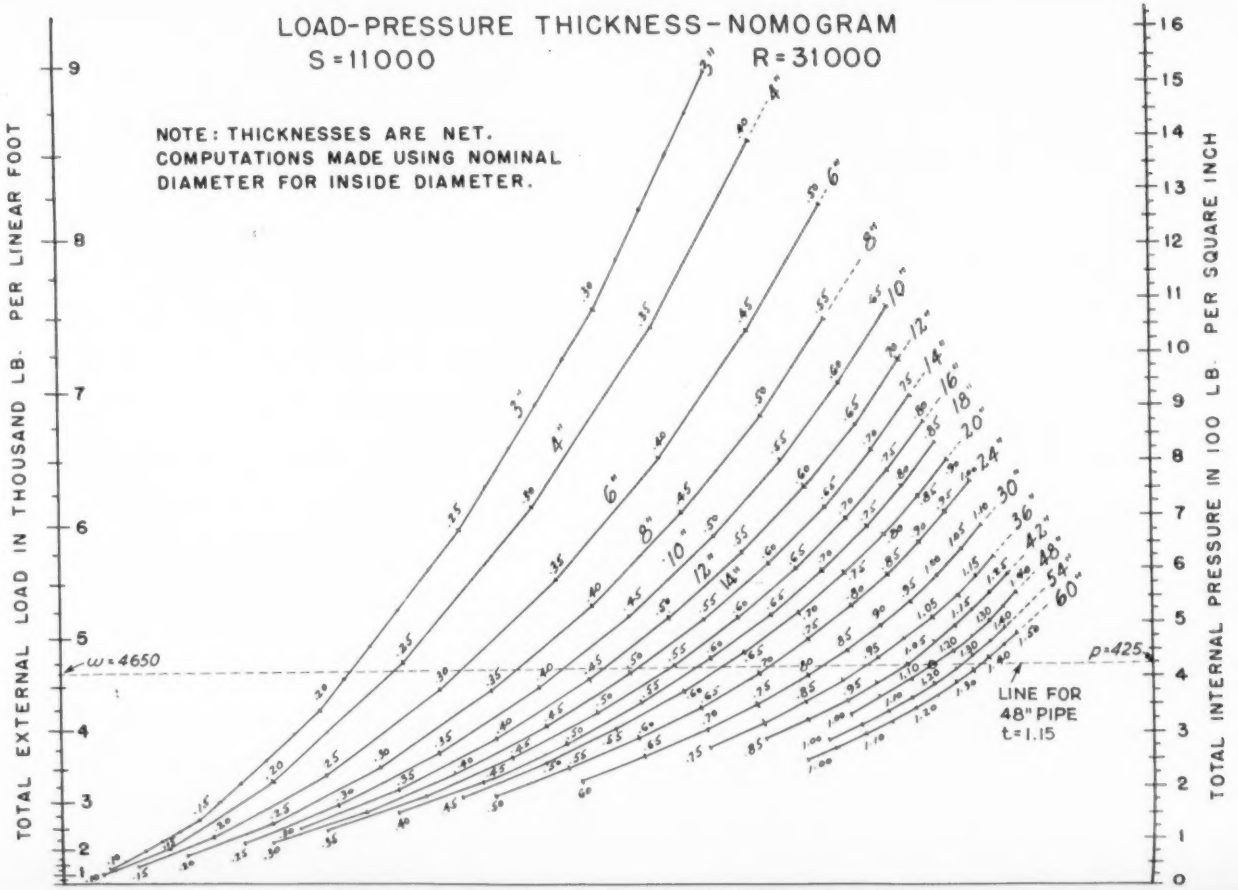
** Note: In cases of the 24″, 36″, 54″, and 60″ pipe, there is a difference of .01 inch between the minimum computed as above and the actual minimum used.

TABLE 2.2

Standard Thickness Classes for Pit Cast Pipe

NOMINAL DIAMETER, INCHES	NUMBER AND PIPE WALL THICKNESSES OF STANDARD THICKNESS CLASSES													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
3	.37	.40	.43	.46	.50	.54	.58	.63	.68	.73	.79	.85	.92	.99
4	.40	.43	.46	.50	.54	.58	.63	.68	.73	.79	.85	.92	.99	1.07
6	.43	.46	.50	.54	.58	.63	.68	.73	.79	.85	.92	.99	1.07	1.16
8	.46	.50	.54	.58	.63	.68	.73	.79	.85	.92	.99	1.07	1.16	1.25
10	.50	.54	.58	.63	.68	.73	.79	.85	.92	.99	1.07	1.16	1.25	1.35
12	.54	.58	.63	.68	.73	.79	.85	.92	.99	1.07	1.16	1.25	1.35	1.46
14	.54	.58	.63	.68	.73	.79	.85	.92	.99	1.07	1.16	1.25	1.35	1.46
16	.58	.63	.68	.73	.79	.85	.92	.99	1.07	1.16	1.25	1.35	1.46	1.58
18	.63	.68	.73	.79	.85	.92	.99	1.07	1.16	1.25	1.35	1.46	1.58	1.71
20	.66	.71	.77	.83	.90	.97	1.05	1.13	1.22	1.32	1.43	1.54	1.66	1.79
24	.74	.80	.86	.93	1.00	1.08	1.17	1.26	1.36	1.47	1.59	1.72	1.86	2.01
30	.87	.94	1.02	1.10	1.19	1.29	1.39	1.50	1.62	1.75	1.89	2.04	2.20	2.38
36	.97	1.05	1.13	1.22	1.32	1.43	1.54	1.66	1.79	1.93	2.08	2.25	2.43	2.62
42	1.07	1.16	1.25	1.35	1.46	1.58	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94
48	1.18	1.27	1.37	1.48	1.60	1.73	1.87	2.02	2.18	2.35	2.54	2.74	2.96	3.20
54	1.30	1.40	1.51	1.63	1.76	1.90	2.05	2.21	2.39	2.58	2.79	3.01	3.25	3.51
60	1.39	1.50	1.62	1.75	1.89	2.04	2.20	2.38	2.57	2.78	3.00	3.24	3.50	3.78

Each class is made 8 per cent heavier than the preceding class, starting with class 1 as the base class



LOAD-PRESSURE THICKNESS-NOMOGRAM
S=11000
R=31000



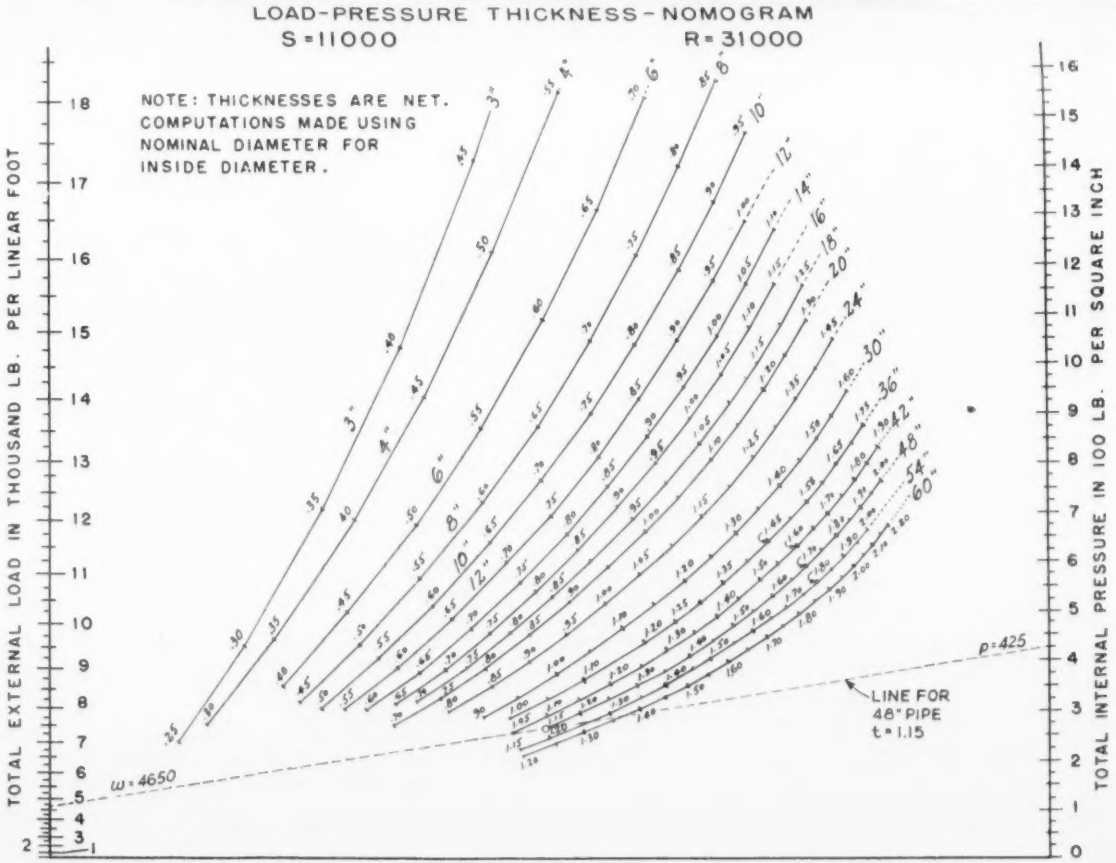


FIG. 2.2. Nomogram. See Example in Sect. 1–11 (g) and Fig. 12 in Manual.

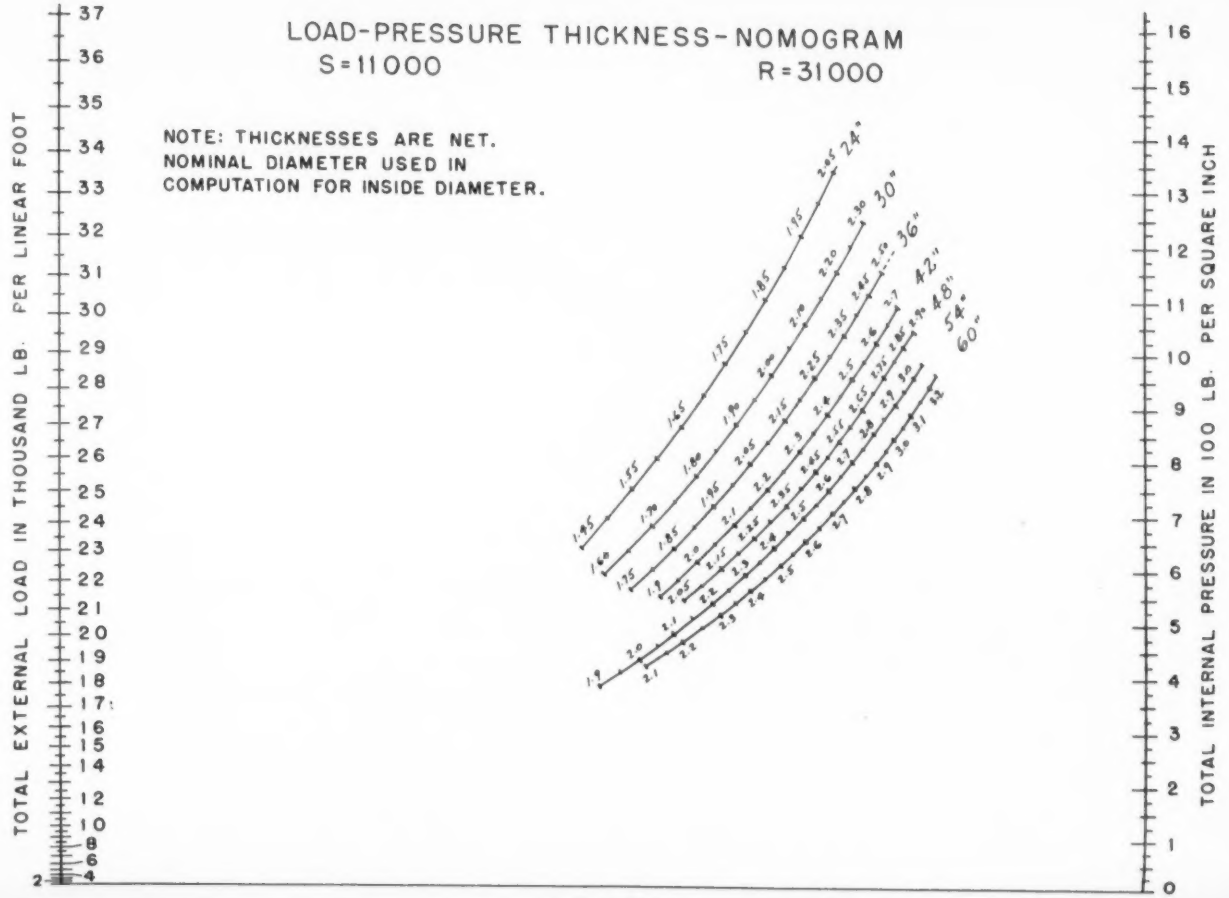

LOAD-PRESSURE THICKNESS-NOMOGRAM
S=11000
R=31000
NOTE: THICKNESSES ARE NET.
NOMINAL DIAMETER USED IN
COMPUTATION FOR INSIDE DIAMETER.
TOTAL EXTERNAL LOAD IN THOUSAND LB. PER LINEAR FOOT
TOTAL INTERNAL PRESSURE IN 100 LB. PER SQUARE INCH
24"
30"
36"
42"
48"
54"
60"

FIG. 2.3

APPENDIX 2A

TABLE 2A.1*

Schedule of Barrel Thicknesses—Field Condition A

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
3	2½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	3½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	5	Calc. Thick.	.25	.26	.26	.27	.29	.31	.32
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	8	Calc. Thick.	.27	.27	.29	.30	.31	.32	.33
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	12	Calc. Thick.	.29	.30	.31	.32	.33	.34	.35
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	16	Calc. Thick.	.31	.32	.33	.34	.35	.35	.36
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
4	2½	Calc. Thick.	*.27	*.28	.30	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	3½	Calc. Thick.	*.27	*.28	.30	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	5	Calc. Thick.	.29	.30	.31	.32	.34	.36	.38
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	8	Calc. Thick.	.31	.32	.33	.34	.35	.37	.39
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	12	Calc. Thick.	.34	.35	.36	.37	.38	.40	.41
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	16	Calc. Thick.	.37	.37	.38	.39	.40	.41	.43
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.40	.40	.40	.40	.40	.40	.43
6	2½	Calc. Thick.	*.33	*.34	*.35	*.37	.41	.44	.47
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.43	.43	.43	.43	.43	.43	.46
	3½	Calc. Thick.	*.32	*.33	.36	.38	.41	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	5	Calc. Thick.	.34	.36	.38	.40	.42	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	8	Calc. Thick.	.38	.40	.41	.43	.45	.48	.51
		Use Thickness Class.	1	1	1	1	2	3	3
		Use Thickness.	.43	.43	.43	.43	.46	.50	.50
	12	Calc. Thick.	.43	.44	.45	.47	.49	.51	.53
		Use Thickness Class.	1	1	2	2	3	3	4
		Use Thickness.	.43	.43	.46	.46	.50	.50	.54
	16	Calc. Thick.	.46	.48	.49	.51	.52	.54	.56
		Use Thickness Class.	2	3	3	3	4	4	5
		Use Thickness.	.46	.50	.50	.50	.54	.54	.58

*Asterisks preceding calculated thicknesses indicate that in such cases truck load rather than water hammer was controlling

TABLE 2A.1 (*cont'd*)

Field Condition A

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
8	2½	Calc. Thick.	*.39	*.40	*.42	.46	.50	.54	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	3½	Calc. Thick.	*.38	*.40	.43	.46	.50	.54	.59
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	5	Calc. Thick.	.41	.43	.46	.49	.52	.56	.60
		Use Thickness Class.	1	1	1	2	3	4	4
		Use Thickness.	.46	.46	.46	.50	.54	.58	.58
	8	Calc. Thick.	.45	.47	.49	.52	.55	.58	.61
		Use Thickness Class.	1	1	2	3	3	4	5
		Use Thickness.	.46	.46	.50	.54	.54	.58	.63
	12	Calc. Thick.	.51	.52	.55	.57	.60	.62	.65
		Use Thickness Class.	2	3	3	4	4	5	5
		Use Thickness.	.50	.54	.54	.58	.58	.63	.63
	16	Calc. Thick.	.55	.56	.58	.60	.63	.65	.68
		Use Thickness Class.	3	4	4	4	5	5	6
		Use Thickness.	.54	.58	.58	.58	.63	.63	.68
10	2½	Calc. Thick.	*.46	*.48	*.50	.54	.58	.64	.69
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	3½	Calc. Thick.	*.44	*.46	.50	.55	.60	.65	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	5	Calc. Thick.	.47	.50	.53	.57	.62	.66	.71
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.50	.50	.54	.58	.63	.68	.73
	8	Calc. Thick.	.53	.56	.59	.62	.66	.70	.74
		Use Thickness Class.	2	3	3	4	5	5	6
		Use Thickness.	.54	.58	.58	.63	.68	.68	.73
	12	Calc. Thick.	.60	.62	.65	.68	.71	.74	.78
		Use Thickness Class.	3	4	4	5	6	6	7
		Use Thickness.	.58	.63	.63	.68	.73	.73	.79
	16	Calc. Thick.	.63	.65	.67	.70	.73	.76	.80
		Use Thickness Class.	4	4	5	5	6	7	7
		Use Thickness.	.63	.63	.68	.68	.73	.79	.79
12	2½	Calc. Thick.	*.51	*.53	*.56	*.60	.66	.72	.79
		Use Thickness Class.	1	1	2	2	4	5	6
		Use Thickness.	.54	.54	.58	.58	.68	.73	.79
	3½	Calc. Thick.	*.49	*.52	.56	.61	.67	.73	.80
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.54	.54	.58	.63	.68	.73	.79
	5	Calc. Thick.	.52	.55	.59	.64	.70	.75	.81
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.54	.54	.58	.63	.68	.73	.79
	8	Calc. Thick.	.60	.63	.66	.70	.74	.79	.84
		Use Thickness Class.	2	3	4	4	5	6	7
		Use Thickness.	.58	.63	.68	.68	.73	.79	.85
	12	Calc. Thick.	.66	.69	.72	.75	.79	.84	.88
		Use Thickness Class.	4	4	5	5	6	7	7
		Use Thickness.	.68	.68	.73	.73	.79	.85	.85
	16	Calc. Thick.	.69	.72	.75	.78	.82	.86	.91
		Use Thickness Class.	4	5	5	6	7	7	8
		Use Thickness.	.68	.73	.73	.79	.85	.85	.92

TABLE 2A.1 (*cont'd*)

Field Condition A

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
14	2½	Calc. Thick.	*.55	*.58	*.61	.67	.75	.82	.90
		Use Thickness Class.	1	2	3	4	5	7	8
		Use Thickness.	.54	.58	.63	.68	.73	.85	.92
	3½	Calc. Thick.	*.54	*.57	.62	.69	.76	.83	.90
		Use Thickness Class.	1	2	3	4	6	7	8
		Use Thickness.	.54	.58	.63	.68	.79	.85	.92
	5	Calc. Thick.	.57	.61	.66	.72	.78	.84	.92
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.58	.63	.68	.73	.79	.85	.92
	8	Calc. Thick.	.67	.70	.75	.79	.84	.90	.96
		Use Thickness Class.	4	4	5	6	7	8	9
		Use Thickness.	.68	.68	.73	.79	.85	.92	.99
	12	Calc. Thick.	.73	.76	.80	.83	.88	.93	.99
		Use Thickness Class.	5	6	6	7	7	8	9
		Use Thickness.	.73	.79	.79	.85	.85	.92	.99
	16	Calc. Thick.	.76	.79	.83	.87	.91	.96	1.01
		Use Thickness Class.	6	6	7	7	8	9	9
		Use Thickness.	.79	.79	.85	.85	.92	.99	.99
16	2½	Calc. Thick.	*.60	*.62	*.66	.72	.81	.90	.98
		Use Thickness Class.	1	2	3	4	5	7	8
		Use Thickness.	.58	.63	.68	.73	.79	.92	.99
	3½	Calc. Thick.	*.59	*.62	.67	.74	.82	.91	.99
		Use Thickness Class.	1	2	3	4	5	7	8
		Use Thickness.	.58	.63	.68	.73	.79	.92	.99
	5	Calc. Thick.	*.62	.66	.72	.78	.85	.93	1.00
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.63	.68	.73	.79	.85	.92	.99
	8	Calc. Thick.	.71	.75	.80	.85	.91	.97	1.04
		Use Thickness Class.	4	4	5	6	7	8	9
		Use Thickness.	.73	.73	.79	.85	.92	.99	1.07
	12	Calc. Thick.	.78	.82	.86	.91	.96	1.01	1.08
		Use Thickness Class.	5	6	6	7	8	8	9
		Use Thickness.	.79	.85	.85	.92	.99	.99	1.07
	16	Calc. Thick.	.83	.86	.90	.94	.99	1.05	1.11
		Use Thickness Class.	6	6	7	7	8	9	9
		Use Thickness.	.85	.85	.92	.92	.99	1.07	1.07
18	2½	Calc. Thick.	*.65	*.68	.71	.79	.88	.98	1.08
		Use Thickness Class.	1	2	3	4	5	7	8
		Use Thickness.	.63	.68	.73	.79	.85	.99	1.07
	3½	Calc. Thick.	*.64	*.67	.73	.81	.90	.99	1.09
		Use Thickness Class.	1	2	3	4	6	7	8
		Use Thickness.	.63	.68	.73	.79	.92	.99	1.07
	5	Calc. Thick.	*.67	.73	.79	.86	.94	1.02	1.11
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.68	.73	.79	.85	.92	.99	1.07
	8	Calc. Thick.	.77	.82	.87	.93	1.00	1.07	1.15
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.79	.85	.85	.92	.99	1.07	1.16
	12	Calc. Thick.	.84	.89	.93	.98	1.05	1.11	1.19
		Use Thickness Class.	5	6	6	7	8	8	9
		Use Thickness.	.85	.92	.92	.99	1.07	1.07	1.16
	16	Calc. Thick.	.89	.93	.98	1.03	1.09	1.15	1.22
		Use Thickness Class.	6	6	7	8	8	9	10
		Use Thickness.	.92	.92	.99	1.07	1.07	1.16	1.25

TABLE 2A.1 (*cont'd*)

Field Condition A

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
20	2½	Calc. Thick.	*.69	*.72	*.77	.84	.94	1.06	1.16
		Use Thickness Class.	2	2	3	4	6	7	8
		Use Thickness.	.71	.71	.77	.83	.97	1.05	1.13
	3½	Calc. Thick.	*.68	*.72	.78	.86	.96	1.07	1.18
		Use Thickness Class.	1	2	3	4	6	7	9
		Use Thickness.	.66	.71	.77	.83	.97	1.05	1.22
	5	Calc. Thick.	.72	.77	.83	.91	1.00	1.11	1.20
		Use Thickness Class.	2	3	4	5	6	8	9
		Use Thickness.	.71	.77	.83	.90	.97	1.13	1.22
	8	Calc. Thick.	.81	.86	.92	.98	1.06	1.14	1.24
		Use Thickness Class.	4	4	5	6	7	8	9
		Use Thickness.	.83	.83	.90	.97	1.05	1.13	1.22
	12	Calc. Thick.	.90	.94	.99	1.06	1.12	1.20	1.28
		Use Thickness Class.	5	6	6	7	8	9	10
		Use Thickness.	.90	.97	.97	1.05	1.13	1.22	1.32
	16	Calc. Thick.	.95	1.00	1.05	1.10	1.17	1.24	1.32
		Use Thickness Class.	6	6	7	8	9	9	10
		Use Thickness.	.97	.97	1.05	1.13	1.22	1.22	1.32
24	2½	Calc. Thick.	*.78	*.82	*.87	.96	1.08	1.21	1.35
		Use Thickness Class.	2	2	3	4	6	7	9
		Use Thickness.	.80	.80	.86	.93	1.08	1.17	1.36
	3½	Calc. Thick.	*.76	*.81	.88	.99	1.11	1.23	1.36
		Use Thickness Class.	1	2	3	5	6	8	9
		Use Thickness.	.74	.80	.86	1.00	1.08	1.26	1.36
	5	Calc. Thick.	*.81	.87	.95	1.05	1.16	1.26	1.38
		Use Thickness Class.	2	3	4	6	7	8	9
		Use Thickness.	.80	.86	.93	1.08	1.17	1.26	1.36
	8	Calc. Thick.	.92	.98	1.05	1.13	1.22	1.32	1.43
		Use Thickness Class.	4	5	6	7	8	9	10
		Use Thickness.	.93	1.00	1.08	1.17	1.26	1.36	1.47
	12	Calc. Thick.	1.01	1.07	1.13	1.20	1.28	1.38	1.48
		Use Thickness Class.	5	6	7	7	8	9	10
		Use Thickness.	1.00	1.08	1.17	1.17	1.26	1.36	1.47
	16	Calc. Thick.	1.08	1.13	1.19	1.26	1.34	1.43	1.52
		Use Thickness Class.	6	7	7	8	9	10	10
		Use Thickness.	1.08	1.17	1.17	1.26	1.36	1.47	1.47
30	2½	Calc. Thick.	*.91	*.97	*1.05	1.17	1.32	1.48	1.65
		Use Thickness Class.	2	2	3	5	6	8	9
		Use Thickness.	.94	.94	1.02	1.19	1.29	1.50	1.62
	3½	Calc. Thick.	*.91	*.97	1.06	1.20	1.33	1.50	1.66
		Use Thickness Class.	2	2	4	5	6	8	9
		Use Thickness.	.94	.94	1.10	1.19	1.29	1.50	1.62
	5	Calc. Thick.	*.97	1.05	1.15	1.26	1.39	1.53	1.68
		Use Thickness Class.	2	3	5	6	7	8	9
		Use Thickness.	.94	1.02	1.19	1.29	1.39	1.50	1.62
	8	Calc. Thick.	1.09	1.17	1.25	1.35	1.47	1.60	1.74
		Use Thickness Class.	4	5	6	7	8	9	10
		Use Thickness.	1.10	1.19	1.29	1.39	1.50	1.62	1.75
	12	Calc. Thick.	1.21	1.28	1.36	1.45	1.56	1.67	1.80
		Use Thickness Class.	5	6	7	8	9	9	10
		Use Thickness.	1.19	1.29	1.39	1.50	1.62	1.62	1.75
	16	Calc. Thick.	1.30	1.37	1.45	1.53	1.63	1.74	1.85
		Use Thickness Class.	6	7	8	8	9	10	11
		Use Thickness.	1.29	1.39	1.50	1.50	1.62	1.75	1.89

TABLE 2A.1 (*cont'd*)

Field Condition A

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
36	2½	Calc. Thick.	*1.04	*1.11	*1.19	1.34	1.53	1.72	1.93
		Use Thickness Class.	2	3	4	5	7	8	10
		Thickness.	1.05	1.13	1.22	1.32	1.54	1.66	1.93
	3½	Calc. Thick.	*1.04	*1.11	1.20	1.37	1.55	1.73	1.94
		Use Thickness Class.	2	3	4	5	7	9	10
		Thickness.	1.05	1.13	1.22	1.32	1.54	1.79	1.93
	5	Calc. Thick.	*1.08	*1.18	1.32	1.43	1.60	1.76	1.95
		Use Thickness Class.	2	4	5	6	8	9	10
		Thickness.	1.05	1.22	1.32	1.43	1.66	1.79	1.93
	8	Calc. Thick.	1.24	1.33	1.43	1.56	1.70	1.85	2.03
		Use Thickness Class.	4	5	6	7	8	9	11
		Thickness.	1.22	1.32	1.43	1.54	1.66	1.79	2.08
	12	Calc. Thick.	1.39	1.47	1.57	1.67	1.80	1.94	2.10
		Use Thickness Class.	6	6	7	8	9	10	11
		Thickness.	1.43	1.43	1.54	1.66	1.79	1.93	2.08
	16	Calc. Thick.	1.50	1.57	1.66	1.77	1.88	2.03	2.16
		Use Thickness Class.	7	7	8	9	10	11	11
		Thickness.	1.54	1.54	1.66	1.79	1.93	2.08	2.08
42	2½	Calc. Thick.	*1.16	*1.24	*1.34	1.50	1.75	1.95	2.20
		Use Thickness Class.	2	3	4	5	7	9	10
		Thickness.	1.16	1.25	1.35	1.46	1.71	2.00	2.16
	3½	Calc. Thick.	*1.16	*1.24	1.35	1.54	1.76	1.97	2.22
		Use Thickness Class.	2	3	4	6	7	9	10
		Thickness.	1.16	1.25	1.35	1.58	1.71	2.00	2.16
	5	Calc. Thick.	*1.24	*1.32	1.46	1.63	1.81	2.02	2.25
		Use Thickness Class.	3	4	5	6	8	9	11
		Thickness.	1.25	1.35	1.46	1.58	1.85	2.00	2.33
	8	Calc. Thick.	1.38	1.48	1.60	1.74	1.92	2.08	2.33
		Use Thickness Class.	4	5	6	7	8	10	11
		Thickness.	1.35	1.46	1.58	1.71	1.85	2.16	2.33
	12	Calc. Thick.	1.56	1.65	1.76	1.89	2.04	2.22	2.39
		Use Thickness Class.	6	7	7	8	9	10	11
		Thickness.	1.58	1.71	1.71	1.85	2.00	2.16	2.33
	16	Calc. Thick.	1.69	1.78	1.88	2.00	2.15	2.30	2.46
		Use Thickness Class.	7	8	8	9	10	11	12
		Thickness.	1.71	1.85	1.85	2.00	2.16	2.33	2.52
48	2½	Calc. Thick.	*1.28	*1.38	*1.48	1.69	1.96	2.22	2.50
		Use Thickness Class.	2	3	4	6	8	9	11
		Thickness.	1.27	1.37	1.48	1.73	2.02	2.18	2.54
	3½	Calc. Thick.	*1.39	*1.38	1.52	1.74	1.98	2.23	2.51
		Use Thickness Class.	2	3	4	6	8	9	11
		Thickness.	1.27	1.37	1.48	1.73	2.02	2.18	2.54
	5	Calc. Thick.	*1.38	*1.47	1.64	1.83	2.05	2.28	2.54
		Use Thickness Class.	3	4	5	7	8	10	11
		Thickness.	1.37	1.48	1.60	1.87	2.02	2.35	2.54
	8	Calc. Thick.	1.54	1.67	1.80	1.95	2.15	2.38	2.62
		Use Thickness Class.	5	6	7	8	9	10	11
		Thickness.	1.60	1.73	1.87	2.02	2.18	2.35	2.54
	12	Calc. Thick.	1.74	1.84	1.97	2.12	2.32	2.50	2.72
		Use Thickness Class.	6	7	8	9	10	11	12
		Thickness.	1.73	1.87	2.02	2.18	2.35	2.54	2.74
	16	Calc. Thick.	1.90	2.00	2.12	2.24	2.42	2.55	2.75
		Use Thickness Class.	7	8	9	9	10	11	12
		Thickness.	1.87	2.02	2.18	2.18	2.35	2.54	2.74

TABLE 2A.1 (*cont'd*)

Field Condition A

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
54	2½	Calc. Thick.	*1.40	*1.51	*1.63	1.88	2.18	2.48	2.78
		Use Thickness Class.	2	3	4	6	8	9	11
		Use Thickness.	1.40	1.51	1.63	1.90	2.21	2.39	2.79
	3½	Calc. Thick.	*1.43	*1.53	*1.67	1.93	2.20	2.53	2.80
		Use Thickness Class.	2	3	4	6	8	10	11
		Use Thickness.	1.40	1.51	1.63	1.90	2.21	2.58	2.79
	5	Calc. Thick.	*1.50	*1.60	1.80	2.01	2.28	2.56	2.83
		Use Thickness Class.	3	4	5	7	8	10	11
		Use Thickness.	1.51	1.63	1.76	2.05	2.21	2.58	2.79
	8	Calc. Thick.	1.69	1.83	2.00	2.18	2.42	2.64	2.91
		Use Thickness Class.	4	6	7	8	9	10	12
		Use Thickness.	1.63	1.90	2.05	2.21	2.39	2.58	3.01
	12	Calc. Thick.	1.93	2.05	2.19	2.36	2.56	2.78	3.03
		Use Thickness Class.	6	7	8	9	10	11	12
		Use Thickness.	1.90	2.05	2.21	2.39	2.58	2.79	3.01
	16	Calc. Thick.	2.10	2.22	2.36	2.50	2.68	2.88	3.13
		Use Thickness Class.	7	8	9	10	10	11	13
		Use Thickness.	2.05	2.21	2.39	2.58	2.58	2.79	3.25
60	2½	Calc. Thick.	*1.50	*1.63	*1.78	2.06	2.38	2.73	3.08
		Use Thickness Class.	2	3	4	6	8	10	11
		Use Thickness.	1.50	1.62	1.75	2.04	2.38	2.78	3.00
	3½	Calc. Thick.	*1.55	*1.68	1.84	2.11	2.45	2.77	3.10
		Use Thickness Class.	2	3	5	6	8	10	11
		Use Thickness.	1.50	1.62	1.89	2.04	2.38	2.78	3.00
	5	Calc. Thick.	*1.64	1.79	1.98	2.20	2.53	2.80	3.13
		Use Thickness Class.	3	4	6	7	9	10	12
		Use Thickness.	1.62	1.75	2.04	2.20	2.57	2.78	3.24
	8	Calc. Thick.	1.85	2.00	2.18	2.38	2.63	2.88	3.21
		Use Thickness Class.	5	6	7	8	9	10	12
		Use Thickness.	1.89	2.04	2.20	2.38	2.57	2.78	3.24
	12	Calc. Thick.	2.10	2.24	2.41	2.58	2.83	3.05	3.33
		Use Thickness Class.	6	7	8	9	10	11	12
		Use Thickness.	2.04	2.20	2.38	2.57	2.78	3.00	3.24
	16	Calc. Thick.	2.29	2.43	2.58	2.75	2.94	3.18	3.41
		Use Thickness Class.	8	8	9	10	11	12	13
		Use Thickness.	2.38	2.38	2.57	2.78	3.00	3.24	3.50

TABLE 2A.2*

Schedule of Barrel Thickness—Field Condition B

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
3	2½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	3½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	5	Calc. Thick.	.25	.26	.26	.27	.29	.31	.32
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	8	Calc. Thick.	.26	.27	.28	.29	.30	.32	.33
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	12	Calc. Thick.	.29	.30	.30	.31	.32	.33	.34
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	16	Calc. Thick.	.31	.31	.32	.33	.34	.35	.36
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
4	2½	Calc. Thick.	*.26	*.27	*.28	.30	.32	.34	.36
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	3½	Calc. Thick.	.26	.27	.29	.31	.32	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	5	Calc. Thick.	.26	.27	.29	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	8	Calc. Thick.	.30	.31	.32	.33	.35	.37	.38
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	12	Calc. Thick.	.32	.33	.35	.36	.37	.39	.40
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	16	Calc. Thick.	.35	.36	.37	.38	.39	.41	.42
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.40	.40	.40	.40	.40	.40	.43
6	2½	Calc. Thick.	.32	.33	.35	.38	.41	.44	.47
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.43	.43	.43	.43	.43	.43	.46
	3½	Calc. Thick.	.32	.33	.35	.38	.41	.44	.48
		Use Thickness Class.	1	1	1	1	1	1	3
		Use Thickness.	.43	.43	.43	.43	.43	.43	.50
	5	Calc. Thick.	.33	.35	.37	.40	.42	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	8	Calc. Thick.	.37	.38	.40	.42	.45	.47	.50
		Use Thickness Class.	1	1	1	1	2	2	3
		Use Thickness.	.43	.43	.43	.43	.46	.46	.50
	12	Calc. Thick.	.41	.42	.44	.46	.48	.50	.52
		Use Thickness Class.	1	1	1	2	3	3	4
		Use Thickness.	.43	.43	.43	.46	.50	.50	.54
	16	Calc. Thick.	.44	.46	.47	.49	.51	.53	.55
		Use Thickness Class.	1	2	2	3	3	4	4
		Use Thickness.	.43	.46	.46	.50	.50	.54	.54

* Asterisks preceding calculated thicknesses indicate that in such cases truck load rather than water hammer was controlling.

TABLE 2A.2 (*cont'd*)

Field Condition B

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
8	2½	Calc. Thick.	*.37	.38	.41	.45	.49	.53	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	3½	Calc. Thick.	*.37	*.38	.42	.46	.50	.54	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	5	Calc. Thick.	.39	.41	.44	.47	.51	.55	.59
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	8	Calc. Thick.	.44	.46	.48	.51	.54	.57	.61
		Use Thickness Class.	1	1	2	2	3	4	5
		Use Thickness.	.46	.46	.50	.50	.54	.58	.63
	12	Calc. Thick.	.49	.50	.52	.55	.58	.61	.64
		Use Thickness Class.	2	2	3	3	4	5	5
		Use Thickness.	.50	.50	.54	.54	.58	.63	.63
	16	Calc. Thick	.52	.54	.56	.58	.60	.63	.66
		Use Thickness Class.	3	3	4	4	4	5	6
		Use Thickness.	.54	.54	.58	.58	.58	.63	.68
10	2½	Calc. Thick.	*.43	*.45	*.48	.53	.59	.64	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	3½	Calc. Thick.	*.42	*.44	.49	.54	.59	.65	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	5	Calc. Thick.	.45	.48	.52	.56	.61	.66	.71
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.50	.50	.54	.58	.63	.68	.73
	8	Calc. Thick.	.51	.53	.57	.60	.64	.68	.73
		Use Thickness Class.	1	2	3	3	4	5	6
		Use Thickness.	.50	.54	.58	.58	.63	.68	.73
	12	Calc. Thick.	.57	.59	.62	.65	.68	.72	.75
		Use Thickness Class.	3	3	4	4	5	6	6
		Use Thickness.	.58	.58	.63	.63	.68	.73	.73
	16	Calc. Thick.	.59	.62	.64	.67	.70	.74	.78
		Use Thickness Class.	3	4	4	5	5	6	7
		Use Thickness.	.58	.63	.63	.68	.68	.73	.79
12	2½	Calc. Thick.	*.49	*.51	.54	.59	.66	.72	.79
		Use Thickness Class.	1	1	1	2	4	5	6
		Use Thickness.	.54	.54	.54	.58	.68	.73	.79
	3½	Calc. Thick.	*.47	*.49	.54	.60	.67	.73	.80
		Use Thickness Class.	1	1	1	2	4	5	6
		Use Thickness.	.54	.54	.54	.58	.68	.73	.79
	5	Calc. Thick.	.50	.53	.58	.62	.68	.74	.81
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.54	.54	.58	.63	.68	.73	.79
	8	Calc. Thick.	.57	.60	.63	.68	.72	.77	.83
		Use Thickness Class.	2	2	3	4	5	6	7
		Use Thickness.	.58	.58	.63	.68	.73	.79	.85
	12	Calc. Thick.	.62	.65	.69	.72	.76	.81	.86
		Use Thickness Class.	3	3	4	5	6	6	7
		Use Thickness.	.63	.63	.68	.73	.79	.79	.85
	16	Calc. Thick.	.65	.68	.71	.75	.79	.83	.87
		Use Thickness Class.	3	4	5	5	6	7	7
		Use Thickness.	.63	.68	.73	.73	.79	.85	.85

TABLE 2A.2 (*cont'd*)

Field Condition B

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
14	2½	Calc. Thick.	*.52	*.54	.59	.66	.74	.82	.89
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.54	.54	.58	.68	.73	.85	.92
	3½	Calc. Thick.	*.51	.55	.61	.67	.75	.82	.90
		Use Thickness Class.	1	1	3	4	5	7	8
		Use Thickness.	.54	.54	.63	.68	.73	.85	.92
	5	Thick.	.54	.59	.64	.70	.77	.83	.91
		Use Thickness Class.	1	2	3	4	6	7	8
		Use Thickness.	.54	.58	.63	.68	.79	.85	.92
	8	Calc. Thick.	.63	.66	.71	.76	.81	.87	.95
		Use Thickness Class.	3	4	5	6	6	7	8
		Use Thickness.	.63	.68	.73	.79	.79	.85	.92
	12	Calc. Thick.	.68	.71	.75	.80	.85	.90	.96
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.68	.73	.73	.79	.85	.92	.99
	16	Calc. Thick.	.71	.75	.78	.82	.87	.92	.98
		Use Thickness Class.	5	5	6	7	7	8	9
		Use Thickness.	.73	.73	.79	.85	.85	.92	.99
16	2½	Calc. Thick.	*.56	*.58	.63	.72	.80	.89	.98
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.58	.58	.63	.73	.79	.92	.99
	3½	Calc. Thick.	*.55	.59	.66	.73	.81	.90	.98
		Use Thickness Class.	1	1	3	4	5	7	8
		Use Thickness.	.58	.58	.68	.73	.79	.92	.99
	5	Calc. Thick.	.58	.63	.69	.76	.84	.91	1.00
		Use Thickness Class.	1	2	3	5	6	7	8
		Use Thickness.	.58	.63	.68	.79	.85	.92	.99
	8	Calc. Thick.	.67	.71	.76	.81	.88	.95	1.02
		Use Thickness Class.	3	4	5	5	6	7	8
		Use Thickness.	.68	.73	.79	.79	.85	.92	.99
	12	Calc. Thick.	.73	.77	.81	.86	.92	.98	1.05
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.73	.79	.79	.85	.92	.99	1.07
	16	Calc. Thick.	.77	.81	.85	.89	.95	1.00	1.07
		Use Thickness Class.	5	5	6	7	7	8	9
		Use Thickness.	.79	.79	.85	.92	.92	.99	1.07
18	2½	Calc. Thick.	*.59	*.63	.69	.78	.88	.98	1.08
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.63	.63	.68	.79	.85	.99	1.07
	3½	Calc. Thick.	*.59	.64	.72	.80	.89	.99	1.08
		Use Thickness Class.	1	1	3	4	6	7	8
		Use Thickness.	.63	.63	.73	.79	.92	.99	1.07
	5	Calc. Thick.	.63	.69	.75	.83	.92	1.01	1.10
		Use Thickness Class.	1	2	3	5	6	7	8
		Use Thickness.	.63	.68	.73	.85	.92	.99	1.07
	8	Calc. Thick.	.72	.77	.82	.88	.96	1.03	1.12
		Use Thickness Class.	3	4	5	5	7	8	9
		Use Thickness.	.73	.79	.85	.85	.99	1.07	1.16
	12	Calc. Thick.	.78	.84	.88	.95	1.00	1.08	1.16
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.79	.85	.85	.92	.99	1.07	1.16
	16	Calc. Thick.	.83	.87	.91	.97	1.03	1.10	1.17
		Use Thickness Class.	5	5	6	7	8	8	9
		Use Thickness.	.85	.85	.92	.99	1.07	1.07	1.16

TABLE 2A.2 (*cont'd*)

Field Condition B

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
20	2½	Calc. Thick.	*.63	*.67	.72	.83	.94	1.05	1.16
		Use Thickness Class.	1	1	2	4	6	7	8
		Use Thickness.	.66	.66	.71	.83	.97	1.05	1.13
	3½	Calc. Thick.	*.62	.67	.76	.85	.95	1.06	1.17
		Use Thickness Class.	1	1	3	4	6	7	8
		Use Thickness.	.66	.66	.77	.83	.97	1.05	1.13
	5	Calc. Thick.	.66	.73	.80	.89	.98	1.08	1.18
		Use Thickness Class.	1	2	4	5	6	7	9
		Use Thickness.	.66	.71	.83	.90	.97	1.05	1.22
	8	Calc. Thick.	.76	.81	.87	.94	1.02	1.11	1.21
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.77	.83	.90	.97	1.05	1.13	1.22
	12	Calc. Thick.	.83	.88	.93	.99	1.07	1.15	1.24
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.83	.90	90	.97	1.05	1.13	1.22
	16	Calc. Thick.	.87	.92	.97	1.04	1.10	1.18	1.26
		Use Thickness Class.	5	5	6	7	8	9	9
		Use Thickness.	.90	.90	.97	1.05	1.13	1.22	1.22
24	2½	Calc. Thick.	*.69	*.75	.82	.95	1.08	1.21	1.34
		Use Thickness Class.	1	1	2	4	6	7	9
		Use Thickness.	.74	.74	.80	.93	1.08	1.17	1.36
	3½	Calc. Thick.	*.69	.75	.85	.97	1.09	1.23	1.36
		Use Thickness Class.	1	1	3	5	6	8	9
		Use Thickness.	.74	.74	.86	1.00	1.08	1.26	1.36
	5	Calc. Thick.	.75	.82	.91	1.01	1.12	1.24	1.36
		Use Thickness Class.	1	2	4	5	6	8	9
		Use Thickness.	.74	.80	.93	1.00	1.08	1.26	1.36
	8	Calc. Thick.	.83	.91	.98	1.07	1.17	1.28	1.39
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.86	.93	1.00	1.08	1.17	1.26	1.36
	12	Calc. Thick.	.91	.98	1.05	1.13	1.21	1.32	1.43
		Use Thickness Class.	4	5	6	7	7	9	10
		Use Thickness.	.93	1.00	1.08	1.17	1.17	1.36	1.47
	16	Calc. Thick.	.98	1.04	1.10	1.18	1.26	1.36	1.46
		Use Thickness Class.	5	6	6	7	8	9	10
		Use Thickness.	1.00	1.08	1.08	1.17	1.26	1.36	1.47
30	2½	Calc. Thick.	*.81	*.87	.99	1.15	1.31	1.48	1.64
		Use Thickness Class.	1	1	3	5	6	8	9
		Use Thickness.	.87	.87	1.02	1.19	1.29	1.50	1.62
	3½	Calc. Thick.	*.81	.88	1.02	1.17	1.32	1.49	1.65
		Use Thickness Class.	1	1	3	5	6	8	9
		Use Thickness.	.87	.87	1.02	1.19	1.29	1.50	1.62
	5	Calc. Thick.	.87	.96	1.08	1.21	1.35	1.51	1.66
		Use Thickness Class.	1	2	4	5	7	8	9
		Use Thickness.	.87	.94	1.10	1.19	1.39	1.50	1.62
	8	Calc. Thick.	.98	1.06	1.16	1.27	1.40	1.55	1.69
		Use Thickness Class.	3	4	5	6	7	8	10
		Use Thickness.	1.02	1.10	1.19	1.29	1.39	1.50	1.75
	12	Calc. Thick.	1.09	1.16	1.25	1.35	1.46	1.60	1.73
		Use Thickness Class.	4	5	6	7	8	9	10
		Use Thickness.	1.10	1.19	1.29	1.39	1.50	1.62	1.75
	16	Calc. Thick.	1.16	1.23	1.30	1.40	1.51	1.64	1.76
		Use Thickness Class.	5	5	6	7	8	9	10
		Use Thickness.	1.19	1.19	1.29	1.39	1.50	1.62	1.75

TABLE 2A.2 (*cont'd*)

Field Condition B

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
36	2½	Calc. Thick.	*.91	*.98	1.13	1.31	1.52	1.72	1.93
		Use Thickness Class.	1	1	3	5	7	8	10
		Use Thickness.	.97	.97	1.13	1.32	1.54	1.66	1.93
	3½	Calc. Thick.	*.91	.99	1.15	1.34	1.52	1.73	1.93
		Use Thickness Class.	1	1	3	5	7	9	10
		Use Thickness.	.97	.97	1.13	1.32	1.54	1.79	1.93
	5	Calc. Thick.	.98	1.09	1.23	1.38	1.54	1.75	1.94
		Use Thickness Class.	1	2	4	6	7	9	10
		Use Thickness.	.97	1.05	1.22	1.43	1.54	1.79	1.93
	8	Calc. Thick.	1.10	1.20	1.32	1.45	1.62	1.78	1.98
		Use Thickness Class.	3	4	5	6	8	9	10
		Use Thickness.	1.13	1.22	1.32	1.43	1.66	1.79	1.93
	12	Calc. Thick.	1.22	1.31	1.42	1.54	1.68	1.84	2.03
		Use Thickness Class.	4	5	6	7	8	9	11
		Use Thickness.	1.22	1.32	1.43	1.54	1.66	1.79	2.08
	16	Calc. Thick.	1.30	1.39	1.49	1.61	1.73	1.88	2.05
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.32	1.43	1.54	1.66	1.79	1.93	2.08
42	2½	Calc. Thick.	*1.00	*1.09	1.26	1.48	1.71	1.94	2.18
		Use Thickness Class.	1	1	3	5	7	9	10
		Use Thickness.	1.07	1.07	1.25	1.46	1.71	2.00	2.16
	3½	Calc. Thick.	*1.01	1.10	1.29	1.50	1.73	1.97	2.21
		Use Thickness Class.	1	1	3	5	7	9	10
		Use Thickness.	1.07	1.07	1.25	1.46	1.71	2.00	2.16
	5	Calc. Thick.	1.07	1.21	1.36	1.55	1.76	1.97	2.23
		Use Thickness Class.	1	3	4	6	7	9	10
		Use Thickness.	1.07	1.25	1.35	1.58	1.71	2.00	2.16
	8	Calc. Thick.	1.20	1.33	1.47	1.63	1.82	2.02	2.25
		Use Thickness Class.	3	4	5	6	8	9	11
		Use Thickness.	1.25	1.35	1.46	1.58	1.85	2.00	2.33
	12	Calc. Thick.	1.35	1.46	1.58	1.73	1.90	2.08	2.29
		Use Thickness Class.	4	5	6	7	8	10	11
		Use Thickness.	1.35	1.46	1.58	1.71	1.85	2.16	2.33
	16	Calc. Thick.	1.45	1.54	1.67	1.80	1.97	2.16	2.34
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.46	1.58	1.71	1.85	2.00	2.16	2.33
48	2½	Calc. Thick.	*1.08	*1.20	1.42	1.68	1.93	2.21	2.48
		Use Thickness Class.	1	1	3	6	7	9	11
		Use Thickness.	1.18	1.18	1.37	1.73	1.87	2.18	2.54
	3½	Calc. Thick.	*1.10	1.23	1.45	1.70	1.95	2.22	2.49
		Use Thickness Class.	1	2	4	6	8	9	11
		Use Thickness.	1.18	1.27	1.48	1.73	2.02	2.18	2.54
	5	Calc. Thick.	1.18	1.33	1.53	1.74	1.98	2.23	2.55
		Use Thickness Class.	1	3	4	6	8	9	11
		Use Thickness.	1.18	1.37	1.48	1.73	2.02	2.18	2.54
	8	Calc. Thick.	1.34	1.47	1.64	1.83	2.04	2.31	2.55
		Use Thickness Class.	3	4	5	7	8	10	11
		Use Thickness.	1.37	1.48	1.60	1.87	2.02	2.35	2.54
	12	Calc. Thick.	1.50	1.63	1.77	1.94	2.13	2.36	2.59
		Use Thickness Class.	4	5	6	7	9	10	11
		Use Thickness.	1.48	1.60	1.73	1.87	2.18	2.35	2.54
	16	Calc. Thick.	1.62	1.74	1.87	2.03	2.23	2.42	2.64
		Use Thickness Class.	5	6	7	8	9	10	12
		Use Thickness.	1.60	1.73	1.87	2.02	2.18	2.35	2.74

TABLE 2A.2 (*cont'd*)

Field Condition B

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
54	2½	Calc. Thick.	*1.19	*1.31	1.57	1.88	2.16	2.46	2.78
		Use Thickness Class.	1	1	4	6	8	9	11
		Use Thickness.	1.30	1.30	1.63	1.90	2.21	2.39	2.79
	3½	Cal. Thick.	*1.22	1.36	1.60	1.89	2.18	2.48	2.78
		Use Thickness Class.	1	2	4	6	8	9	11
		Use Thickness..	1.30	1.40	1.63	1.90	2.21	2.39	2.79
	5	Calc. Thick.	1.29	1.48	1.68	1.96	2.22	2.52	2.80
		Use Thickness Class.	1	3	4	6	8	10	11
		Use Thickness.	1.30	1.51	1.63	1.90	2.21	2.58	2.79
	8	Calc. Thick.	1.46	1.62	1.80	2.03	2.29	2.55	2.83
		Use Thickness Class.	3	4	5	7	8	10	11
		Use Thickness.	1.51	1.63	1.76	2.05	2.21	2.58	2.79
	12	Calc. Thick.	1.63	1.78	1.95	2.15	2.39	2.63	2.89
		Use Thickness Class.	4	5	6	8	9	10	11
		Use Thickness.	1.63	1.76	1.90	2.21	2.39	2.58	2.79
	16	Calc. Thick.	1.77	1.92	2.06	2.28	2.46	2.68	2.95
		Use Thickness Class.	5	6	7	8	9	10	12
		Use Thickness.	1.76	1.90	2.05	2.21	2.39	2.58	3.01
60	2½	Calc. Thick.	*1.28	1.42	1.73	2.05	2.38	2.73	3.08
		Use Thickness Class.	1	1	4	6	8	10	11
		Use Thickness.	1.39	1.39	1.75	2.04	2.38	2.78	3.00
	3½	Calc. Thick.	*1.32	1.47	1.78	2.07	2.39	2.73	3.08
		Use Thickness Class.	1	2	4	6	8	10	11
		Use Thickness.	1.39	1.50	1.75	2.04	2.38	2.78	3.00
	5	Calc. Thick.	1.40	1.59	1.84	2.12	2.43	2.75	3.08
		Use Thickness Class.	1	3	5	7	8	10	11
		Use Thickness.	1.39	1.62	1.89	2.20	2.38	2.78	3.00
	8	Calc. Thick.	1.59	1.77	1.98	2.22	2.49	2.79	3.12
		Use Thickness Class.	3	4	6	7	9	10	12
		Use Thickness.	1.62	1.75	2.04	2.20	2.57	2.78	3.24
	12	Calc. Thick.	1.80	1.95	2.13	2.36	2.60	2.87	3.18
		Use Thickness Class.	4	5	7	8	9	10	12
		Use Thickness.	1.75	1.89	2.20	2.38	2.57	2.78	3.24
	16	Calc. Thick.	1.93	2.08	2.26	2.46	2.68	2.95	3.26
		Use Thickness Class.	5	6	7	8	10	11	12
		Use Thickness.	1.89	2.04	2.20	2.38	2.78	3.00	3.24

TABLE 2A.3 *

Schedule of Barrel Thicknesses—Field Condition C

Blocks Having Average Spacing of 6 feet

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN. p						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
3	2½	Calc. Thick.	*.36	*.36	*.37	*.37	*.38	*.39	*.39
		Use Thickness Class.	1	1	1	1	1	2	2
		Use Thickness.	.37	.37	.37	.37	.37	.40	.40
	3½	Calc. Thick.	*.36	*.36	*.37	*.37	*.38	*.38	*.39
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.37	.37	.37	.37	.37	.37	.40
	5	Calc. Thick.	*.38	*.38	*.39	*.39	*.40	*.40	*.41
		Use Thickness Class.	1	1	2	2	2	2	2
		Use Thickness.	.37	.37	.40	.40	.40	.40	.40
	8	Calc. Thick.	.43	.43	.44	.44	.45	.46	.47
		Use Thickness Class.	3	3	3	3	4	4	4
		Use Thickness.	.43	.43	.43	.43	.46	.46	.46
	12	Calc. Thick.	See page 21 for thickness classes required.					.52	.52
		Std. Class No.						6	6
		Std. Class Thick.						.54	.54
	16	Calc. Thick.	See page 21 for thickness classes required.						
		Std. Class No.							
		Std. Class Thick.							
4	2½	Calc. Thick.	*.40	*.41	*.41	*.42	*.43	*.44	*.45
		Use Thickness Class.	1	1	1	2	2	2	3
		Use Thickness.	.40	.40	.40	.43	.43	.43	.46
	3½	Calc. Thick.	*.40	*.40	*.41	*.42	*.43	*.44	*.45
		Use Thickness Class.	1	1	1	2	2	2	3
		Use Thickness.	.40	.40	.40	.43	.43	.43	.46
	5	Calc. Thick.	*.42	*.43	*.44	*.44	*.45	*.46	*.47
		Use Thickness Class.	2	2	2	2	3	3	3
		Use Thickness.	.43	.43	.43	.43	.46	.46	.46
	8	Calc. Thick.	.48	.49	.50	.50	.51	.52	.53
		Use Thickness Class.	4	4	4	4	4	5	5
		Use Thickness.	.50	.50	.50	.50	.50	.54	.54
	12	Calc. Thick.	.56	.56	.57	.58	.59	.60	.60
		Use Thickness Class.	6	6	6	6	6	6	6
		Use Thickness.	.58	.58	.58	.58	.58	.58	.58
	16	Calc. Thick.	.62	.63	.64	.64	.65	.66	.67
		Use Thickness Class.	7	7	7	7	7	8	8
		Use Thickness.	.63	.63	.63	.63	.63	.68	.68

All thicknesses given above for 3-inch and 4-inch pipe are safe for the most favorable block spacing, viz. 30 inches from each end of 12-foot length of pipe or, if longer lengths are used, spacing which does not give greater beam moments, and which averages not over 6 feet. In many cases thicknesses given for 3-inch and 4-inch pipe are not safe for less favorable block spacings. For thicknesses required with less favorable block spacings with 12-foot lengths of pipe, see page 21.

* Asterisks preceding calculated thicknesses indicate that in such cases truck load rather than water hammer was controlling.

TABLE 2A.3 (*cont'd*)

Schedule of Barrel Thicknesses—Field Condition C

Blocks Having Average Spacing of 6 feet

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
6	2½	Calc. Thick.	*.46	*.47	*.48	*.50	*.51	*.52	*.54
		Use Thickness Class.	2	2	3	3	3	4	4
		Use Thickness.	.46	.46	.50	.50	.50	.54	.54
	3½	Calc. Thick.	*.46	*.47	*.48	*.49	*.51	*.52	*.54
		Use Thickness Class.	2	2	3	3	3	4	4
		Use Thickness.	.46	.46	.50	.50	.50	.54	.54
	5	Calc. Thick.	*.49	*.50	*.51	*.52	*.53	*.55	.57
		Use Thickness Class.	3	3	3	4	4	4	5
		Use Thickness.	.50	.50	.50	.54	.54	.54	.58
	8	Calc. Thick.	.56	.57	.58	.60	.62	.63	.64
		Use Thickness Class.	5	5	5	5	6	6	6
		Use Thickness.	.58	.58	.58	.58	.63	.63	.63
	12	Calc. Thick.	.65	.66	.67	.68	.70	.71	.73
		Use Thickness Class.	y6	7	7	7	7	8	8
		Use Thickness.	.63	.68	.68	.68	.68	.73	.73
	16	Calc. Thick.	.73	.74	.75	.76	.77	.79	.80
		Use Thickness Class.	y8	y8	y8	y9	y9	y9	y9
		Use Thickness.	.73	.73	.73	.79	.79	.79	.79
8	2½	Calc. Thick.	*.52	*.53	*.54	*.56	*.58	*.60	*.62
		Use Thickness Class.	3	3	3	4	4	4	5
		Use Thickness.	.54	.54	.54	.58	.58	.58	.63
	3½	Calc. Thick.	*.51	*.52	*.54	*.56	*.58	*.61	*.63
		Use Thickness Class.	2	3	3	4	4	5	5
		Use Thickness.	.50	.54	.54	.58	.58	.63	.63
	5	Calc. Thick.	*.54	*.55	*.57	.59	.61	.64	.67
		Use Thickness Class.	3	3	4	4	5	5	6
		Use Thickness.	.54	.54	.58	.58	.63	.63	.68
	8	Calc. Thick.	.62	.64	.66	.68	.69	.72	.74
		Use Thickness Class.	5	5	6	6	6	7	7
		Use Thickness.	.63	.63	.68	.68	.68	.73	.73
	12	Calc. Thick.	.73	.74	.76	.78	.79	.82	.84
		Use Thickness Class.	7	7	8	8	8	9	9
		Use Thickness.	.73	.73	.79	.79	.79	.85	.85
	16	Calc. Thick.	.79	.81	.82	.84	.86	.88	.90
		Use Thickness Class.	8	8	9	9	9	9	10
		Use Thickness.	.79	.79	.85	.85	.85	.85	.92

Thicknesses of 6-inch pipe marked y are not safe for all block spacings though safe for the most favorable block spacing (see note page 19). For thicknesses required with 12-foot lengths in cases marked y see page 19.

TABLE 2A.3 (*cont'd*)
SUPPLEMENTARY THICKNESS TABLE

For Small Pipe Acting as Beams Spanning between Blocks in Field Condition C

Modulus of Rupture of Iron in Pipe as Beam—26,000 lb. per sq. in.

Explanatory Note. This table contains thickness classes computed as required for pipe as beams spanning between blocks, assuming no support from the untamped backfill which will run under the pipe. Net thicknesses, i.e., thicknesses with combined foundry tolerance and corrosion allowances of 0.16 inch deducted from standard thickness, are used in computing beam strengths. Required thickness classes are given for both favorable and unfavorable block spacings. Thickness classes here given should be used where they are larger than those shown in the previous sheets in which the pipe were computed as rings subjected to water pressure and fill loads, disregarding beam.

DISTANCES OF BLOCKS FROM ENDS OF 12-FOOT LENGTHS OF PIPE, INCHES	NOMINAL DIAMETER OF PIPE, INCHES	DEPTH OF COVER—FEET					
		2½	3½	5	8	12	16
21	3	6**	6**	9**	x	x	x
	4	2†	2†	4**	10**	x	x
	6	1	1	1	3	7†	x
	8	1	1	1	1	2	4
30 (most favorable)	3	1	1	1	2	6†	x
	4	1	1	1	1	3	7
	6	1	1	1	1	1	1
	8	1	1	1	1	1	1
36	3	1	1	2†	6	x	x
	4	1	1	1	3	8	x
	6	1	1	1	1	1	4
	8	1	1	1	1	1	1
12 & 30	3	6**	6**	9**	x	x	x
	4	1	1	4**	9**	x	x
	6	1	1	1	2	7†	x
	8	1	1	1	1	2	4

** Heavier than required for pipe as ring with same cover and all water pressures up to and including 350 lb.

† Heavier than required for pipe computed as a ring with the same cover and one or more of the several water pressures.

x No class heavy enough.

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
10	2½	Calc. Thick.	*.57	*.59	*.61	*.63	*.65	*.68	*.71
		Use Thickness Class.	3	3	4	4	4	5	6
		Use Thickness.	.58	.58	.63	.63	.63	.68	.73
	3½	Calc. Thick.	*.56	*.58	*.60	*.62	*.65	*.69	*.73
		Use Thickness Class.	3	3	3	4	4	5	6
		Use Thickness.	.58	.58	.58	.63	.63	.68	.73
	5	Calc. Thick.	*.59	*.61	.64	.67	.70	.74	.78
		Use Thickness Class.	3	4	4	5	5	6	7
		Use Thickness.	.58	.63	.63	.68	.68	.73	.79
	8	Calc. Thick.	.69	.71	.73	.76	.79	.81	.84
		Use Thickness Class.	5	6	6	7	7	7	8
		Use Thickness.	.68	.73	.73	.79	.79	.79	.85
	12	Calc. Thick.	.80	.81	.84	.86	.88	.91	.94
		Use Thickness Class.	7	7	8	8	8	9	9
		Use Thickness.	.79	.79	.85	.85	.85	.92	.92
	16	Calc. Thick.	.84	.86	.88	.90	.93	.95	.98
		Use Thickness Class.	8	8	8	9	9	9	10
		Use Thickness.	.85	.85	.85	.92	.92	.92	.99

TABLE 2A.3 (*cont'd*)

Field Condition C

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
12	2½	Calc. Thick.	*.61	*.63	*.65	*.68	*.71	.75	.81
		Use Thickness Class.	3	3	3	4	5	5	6
		Use Thickness.	.63	.63	.63	.68	.73	.73	.79
	3½	Calc. Thick.	*.60	*.62	*.64	*.67	.71	.77	.82
		Use Thickness Class.	2	3	3	4	5	6	7
		Use Thickness.	.58	.63	.63	.68	.73	.79	.85
	5	Calc. Thick.	*.63	*.65	.69	.72	.76	.81	.86
		Use Thickness Class.	3	3	4	5	6	6	7
		Use Thickness.	.63	.63	.68	.73	.79	.79	.85
	8	Calc. Thick	.74	.76	.79	.82	.86	.89	.94
		Use Thickness Class.	5	6	6	7	7	8	8
		Use Thickness.	.73	.79	.79	.85	.85	.92	.92
	12	Calc. Thick.	.82	.84	.87	.91	.94	.97	1.01
		Use Thickness Class.	7	7	7	8	8	9	9
		Use Thickness.	.85	.85	.85	.92	.92	.99	.99
	16	Calc. Thick.	.87	.90	.92	.95	.98	1.01	1.05
		Use Thickness Class.	7	8	8	8	9	9	10
		Use Thickness.	.85	.92	.92	.92	.99	.99	1.07
14	2½	Calc. Thick.	*.65	*.67	*.70	*.73	*.77	.83	.91
		Use Thickness Class.	3	4	4	5	6	7	8
		Use Thickness.	.63	.68	.68	.73	.79	.85	.92
	3½	Calc. Thick.	*.64	*.67	*.70	.73	.79	.85	.92
		Use Thickness Class.	3	4	4	5	6	7	8
		Use Thickness.	.63	.68	.68	.73	.79	.85	.92
	5	Calc. Thick.	*.68	.71	.75	.79	.85	.90	.96
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.68	.73	.73	.79	.85	.92	.99
	8	Calc. Thick.	.80	.83	.86	.90	.94	.99	1.04
		Use Thickness Class.	6	7	7	8	8	9	10
		Use Thickness.	.79	.85	.85	.92	.92	.99	1.07
	12	Calc. Thick	.87	.90	.93	.97	1.01	1.05	1.10
		Use Thickness Class.	7	8	8	9	9	10	10
		Use Thickness.	.85	.92	.92	.99	.99	1.07	1.07
	16	Calc. Thick	.92	.95	.98	1.02	1.05	1.09	1.14
		Use Thickness Class.	8	8	9	9	10	10	11
		Use Thickness.	.92	.92	.99	.99	1.07	1.07	1.16
16	2½	Calc. Thick.	*.68	*.71	*.74	*.78	*.83	.90	1.00
		Use Thickness Class.	3	4	4	5	6	7	8
		Use Thickness.	.68	.73	.73	.79	.85	.92	.99
	3½	Calc. Thick.	*.68	*.71	*.75	.78	.85	.92	1.01
		Use Thickness Class.	3	4	4	5	6	7	8
		Use Thickness.	.68	.73	.73	.79	.85	.92	.99
	5	Calc. Thick.	*.72	*.75	.79	.85	.91	.97	1.04
		Use Thickness Class.	4	4	5	6	7	8	9
		Use Thickness.	.73	.73	.79	.85	.92	.99	1.07
	8	Calc. Thick.	.83	.87	.91	.95	1.00	1.06	1.12
		Use Thickness Class.	6	6	7	7	8	9	10
		Use Thickness.	.85	.85	.92	.92	.99	1.07	1.16
	12	Calc. Thick.	.92	.95	.99	1.03	1.07	1.12	1.18
		Use Thickness Class.	7	7	8	9	9	10	10
		Use Thickness.	.92	.92	.99	1.07	1.07	1.16	1.16
	16	Calc. Thick.	.97	1.00	1.04	1.08	1.12	1.17	1.23
		Use Thickness Class.	8	8	9	9	10	10	11
		Use Thickness.	.99	.99	1.07	1.07	1.16	1.16	1.25

TABLE 2A.3 (*cont'd*)

Field Condition C

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
18	2½	Calc. Thick.	*.73	*.76	*.80	*.84	.90	.99	1.09
		Use Thickness Class.	3	4	4	5	6	7	8
		Use Thickness.	.73	.79	.79	.85	.92	.99	1.07
	3½	Calc. Thick.	*.72	*.75	*.79	.85	.93	1.02	1.11
		Use Thickness Class.	3	3	4	5	6	7	8
		Use Thickness.	.73	.73	.79	.85	.92	.99	1.07
	5	Calc. Thick.	*.77	*.80	.86	.92	.99	1.06	1.14
		Use Thickness Class.	4	4	5	6	7	8	9
		Use Thickness.	.79	.79	.85	.92	.99	1.07	1.16
	8	Calc. Thick.	.88	.92	.97	1.02	1.08	1.14	1.21
		Use Thickness Class.	5	6	7	7	8	9	10
		Use Thickness.	.85	.92	.99	.99	1.07	1.16	1.25
	12	Calc. Thick.	.96	1.01	1.05	1.10	1.15	1.21	1.27
		Use Thickness Class.	7	7	8	8	9	10	10
		Use Thickness.	.99	.99	1.07	1.07	1.16	1.25	1.25
	16	Calc. Thick.	1.03	1.07	1.11	1.15	1.20	1.26	1.32
		Use Thickness Class.	8	8	8	9	9	10	11
		Use Thickness.	1.07	1.07	1.07	1.16	1.16	1.25	1.35
20	2½	Calc. Thick.	*.77	*.81	*.85	*.90	.96	1.06	1.17
		Use Thickness Class.	3	4	4	5	6	7	8
		Use Thickness.	.77	.83	.83	.90	.97	1.05	1.13
	3½	Calc. Thick.	*.77	*.81	*.85	.90	.99	1.08	1.19
		Use Thickness Class.	3	4	4	5	6	7	9
		Use Thickness.	.77	.83	.83	.90	.97	1.05	1.22
	5	Calc. Thick.	*.81	*.85	.91	.97	1.06	1.14	1.23
		Use Thickness Class.	4	4	5	6	7	8	9
		Use Thickness.	.83	.83	.90	.97	1.05	1.13	1.22
	8	Calc. Thick.	.91	.96	1.02	1.07	1.14	1.21	1.29
		Use Thickness Class.	5	6	7	7	8	9	10
		Use Thickness.	.90	.97	1.05	1.05	1.13	1.22	1.32
	12	Calc. Thick.	1.02	1.06	1.11	1.16	1.22	1.29	1.36
		Use Thickness Class.	7	7	8	8	9	10	10
		Use Thickness.	1.05	1.05	1.13	1.13	1.22	1.32	1.32
	16	Calc. Thick.	1.09	1.13	1.17	1.22	1.28	1.35	1.41
		Use Thickness Class.	8	8	8	9	10	10	11
		Use Thickness.	1.13	1.13	1.13	1.22	1.32	1.32	1.43
24	2½	Calc. Thick.	*.85	*.89	*.94	*1.00	1.10	1.23	1.35
		Use Thickness Class.	3	3	4	5	6	8	9
		Use Thickness.	.86	.86	.93	1.00	1.08	1.26	1.36
	3½	Calc. Thick.	*.85	*.89	*.94	1.02	1.13	1.25	1.37
		Use Thickness Class.	3	3	4	5	7	8	9
		Use Thickness.	.86	.86	.93	1.00	1.17	1.26	1.36
	5	Calc. Thick.	*.89	*.94	1.02	1.10	1.19	1.30	1.41
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.86	.93	1.00	1.08	1.17	1.26	1.36
	8	Calc. Thick.	1.01	1.06	1.12	1.20	1.28	1.37	1.48
		Use Thickness Class.	5	6	6	7	8	9	10
		Use Thickness.	1.00	1.08	1.08	1.17	1.26	1.36	1.47
	12	Calc. Thick.	1.13	1.18	1.24	1.30	1.37	1.46	1.55
		Use Thickness Class.	7	7	8	8	9	10	11
		Use Thickness.	1.17	1.17	1.26	1.26	1.36	1.47	1.59
	16	Calc. Thick.	1.20	1.26	1.31	1.37	1.44	1.52	1.60
		Use Thickness Class.	7	8	9	9	10	10	11
		Use Thickness.	1.17	1.26	1.36	1.36	1.47	1.47	1.59

TABLE 2A.3 (*cont'd*)

Field Condition C

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN. 50	100	150	200	250	300	350
			Barrel thicknesses in inches						
30	2½	Calc. Thick.	*.99	*1.05	*1.11	1.19	1.33	1.49	1.65
		Use Thickness Class.	3	3	4	5	6	8	9
		Use Thickness.	1.02	1.02	1.10	1.19	1.29	1.50	1.62
	3½	Calc. Thick.	*.99	*1.04	*1.11	1.21	1.36	1.51	1.67
		Use Thickness Class.	3	3	4	5	7	8	9
		Use Thickness.	1.02	1.02	1.10	1.19	1.39	1.50	1.62
	5	Calc. Thick.	*1.04	*1.13	1.21	1.32	1.46	1.58	1.73
		Use Thickness Class.	3	4	5	6	8	9	10
		Use Thickness.	1.02	1.10	1.19	1.29	1.50	1.62	1.75
	8	Calc. Thick.	1.18	1.25	1.35	1.43	1.54	1.66	1.78
		Use Thickness Class.	5	6	7	7	8	9	10
		Use Thickness.	1.19	1.29	1.39	1.39	1.50	1.62	1.75
	12	Calc. Thick.	1.32	1.38	1.46	1.54	1.63	1.74	1.87
		Use Thickness Class.	6	7	8	8	9	10	11
		Use Thickness.	1.29	1.39	1.50	1.50	1.62	1.75	1.89
	16	Calc. Thick.	1.41	1.48	1.55	1.62	1.71	1.81	1.92
		Use Thickness Class.	7	8	8	9	10	10	11
		Use Thickness.	1.39	1.50	1.50	1.62	1.75	1.75	1.89
36	2½	Calc. Thick.	*1.11	*1.18	*1.26	1.36	1.53	1.73	1.93
		Use Thickness Class.	3	4	4	5	7	9	10
		Use Thickness.	1.13	1.22	1.22	1.32	1.54	1.79	1.93
	3½	Calc. Thick.	*1.11	*1.18	*1.26	1.40	1.58	1.74	1.94
		Use Thickness Class.	3	4	4	6	7	9	10
		Use Thickness.	1.13	1.22	1.22	1.43	1.54	1.79	1.93
	5	Calc. Thick.	*1.18	*1.25	1.35	1.44	1.65	1.81	2.01
		Use Thickness Class.	4	4	5	6	8	9	11
		Use Thickness.	1.22	1.22	1.32	1.43	1.66	1.79	2.08
	8	Calc. Thick.	1.31	1.40	1.50	1.62	1.75	1.90	2.08
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.32	1.43	1.54	1.66	1.79	1.93	2.08
	12	Calc. Thick.	1.49	1.56	1.65	1.76	1.88	2.01	2.15
		Use Thickness Class.	7	7	8	9	10	11	11
		Use Thickness.	1.54	1.54	1.66	1.79	1.93	2.08	2.08
	16	Calc. Thick.	1.61	1.68	1.77	1.87	1.98	2.09	2.23
		Use Thickness Class.	8	8	9	10	10	11	12
		Use Thickness.	1.66	1.66	1.79	1.93	1.93	2.08	2.25
42	2½	Calc. Thick.	*1.23	*1.31	*1.40	1.52	1.74	1.96	2.23
		Use Thickness Class.	3	4	4	6	7	9	10
		Use Thickness.	1.25	1.35	1.35	1.58	1.71	2.00	2.16
	3½	Calc. Thick.	*1.25	*1.32	*1.41	1.58	1.78	1.98	2.23
		Use Thickness Class.	3	4	5	6	8	9	10
		Use Thickness.	1.25	1.35	1.46	1.58	1.85	2.00	2.16
	5	Calc. Thick.	*1.32	*1.40	1.51	1.66	1.84	2.05	2.28
		Use Thickness Class.	4	4	5	7	8	9	11
		Use Thickness.	1.35	1.35	1.46	1.71	1.85	2.00	2.33
	8	Calc. Thick.	1.47	1.57	1.68	1.81	1.97	2.16	2.36
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.46	1.58	1.71	1.85	2.00	2.16	2.33
	12	Calc. Thick.	1.65	1.74	1.85	1.97	2.11	2.28	2.45
		Use Thickness Class.	7	7	8	9	10	11	12
		Use Thickness.	1.71	1.71	1.85	2.00	2.16	2.33	2.52
	16	Calc. Thick.	1.80	1.88	1.98	2.09	2.23	2.38	2.54
		Use Thickness Class.	8	8	9	10	10	11	12
		Use Thickness.	1.85	1.85	2.00	2.16	2.16	2.33	2.52

TABLE 2A.3 (*cont'd*)

Field Condition C

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
48	2½	Calc. Thick.	*1.34	*1.44	*1.55	1.71	1.96	2.23	2.56
		Use Thickness Class.	3	4	5	6	8	9	11
		Use Thickness.	1.37	1.48	1.60	1.73	2.02	2.18	2.54
	3½	Calc. Thick.	*1.35	*1.45	*1.56	1.76	1.99	2.25	2.52
		Use Thickness Class.	3	4	5	6	8	9	11
		Use Thickness.	1.37	1.48	1.60	1.73	2.02	2.18	2.54
	5	Calc. Thick.	*1.45	*1.55	1.69	1.87	2.08	2.32	2.57
		Use Thickness Class.	4	5	6	7	8	10	11
		Use Thickness.	1.48	1.60	1.73	1.87	2.02	2.35	2.54
	8	Calc. Thick.	1.63	1.74	1.88	2.03	2.22	2.42	2.65
		Use Thickness Class.	5	6	7	8	9	10	12
		Use Thickness.	1.60	1.73	1.87	2.02	2.18	2.35	2.74
	12	Calc. Thick.	1.85	1.95	2.07	2.22	2.38	2.56	2.75
		Use Thickness Class.	7	8	8	9	10	11	12
		Use Thickness.	1.87	2.02	2.02	2.18	2.35	2.54	2.74
	16	Calc. Thick.	2.03	2.13	2.24	2.35	2.50	2.68	2.84
		Use Thickness Class.	8	9	9	10	11	12	12
		Use Thickness.	2.02	2.18	2.18	2.35	2.54	2.74	2.74
54	2½	Calc. Thick.	*1.48	*1.58	*1.72	1.91	2.18	2.48	2.78
		Use Thickness Class.	3	4	5	6	8	9	11
		Use Thickness.	1.51	1.63	1.76	1.90	2.21	2.39	2.79
	3½	Calc. Thick.	*1.52	*1.63	*1.75	1.98	2.23	2.53	2.80
		Use Thickness Class.	3	4	5	7	8	10	11
		Use Thickness.	1.51	1.63	1.76	2.05	2.21	2.58	2.79
	5	Calc. Thick.	*1.60	*1.70	1.87	2.08	2.33	2.58	2.85
		Use Thickness Class.	4	5	6	7	9	10	11
		Use Thickness.	1.63	1.76	1.90	2.05	2.39	2.58	2.79
	8	Calc. Thick.	1.79	1.93	2.08	2.26	2.46	2.69	2.95
		Use Thickness Class.	5	6	7	8	9	11	12
		Use Thickness.	1.76	1.90	2.05	2.21	2.39	2.79	3.01
	12	Calc. Thick.	2.03	2.15	2.28	2.45	2.63	2.84	3.08
		Use Thickness Class.	7	8	8	9	10	11	12
		Use Thickness.	2.05	2.21	2.21	2.39	2.58	2.79	3.01
	16	Calc. Thick.	2.23	2.34	2.47	2.61	2.78	2.98	3.19
		Use Thickness Class.	8	9	9	10	11	12	13
		Use Thickness.	2.21	2.39	2.39	2.58	2.79	3.01	3.25
60	2½	Calc. Thick.	*1.58	*1.72	*1.87	2.08	2.43	2.73	3.08
		Use Thickness Class.	3	4	5	6	8	10	11
		Use Thickness.	1.62	1.75	1.89	2.04	2.38	2.78	3.00
	3½	Calc. Thick.	*1.64	*1.78	*1.91	2.16	2.47	2.78	3.09
		Use Thickness Class.	3	4	5	7	8	10	11
		Use Thickness.	1.62	1.75	1.89	2.20	2.38	2.78	3.00
	5	Calc. Thick.	*1.73	*1.85	2.04	2.28	2.53	2.83	3.13
		Use Thickness Class.	4	5	6	7	9	10	12
		Use Thickness.	1.75	1.89	2.04	2.20	2.57	2.78	3.24
	8	Calc. Thick.	1.95	2.10	2.27	2.46	2.71	2.95	3.24
		Use Thickness Class.	5	6	7	8	10	11	12
		Use Thickness.	1.89	2.04	2.20	2.38	2.78	3.00	3.24
	12	Calc. Thick.	2.24	2.38	2.52	2.69	2.89	3.14	3.38
		Use Thickness Class.	7	8	9	10	11	12	13
		Use Thickness.	2.20	2.38	2.57	2.78	3.00	3.24	3.50
	16	Calc. Thick.	2.43	2.55	2.70	2.86	3.05	3.28	3.52
		Use Thickness Class.	8	9	10	10	11	12	13
		Use Thickness.	2.38	2.57	2.78	2.78	3.00	3.24	3.50

TABLE 2A.4*

Schedule of Barrel Thicknesses—Field Condition D

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
3	2½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	3½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	5	Calc. Thick.	.25	.26	.26	.27	.29	.31	.32
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	8	Calc. Thick.	.27	.27	.29	.30	.31	.32	.33
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	12	Calc. Thick.	.29	.30	.31	.31	.32	.33	.35
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	16	Calc. Thick.	.31	.32	.32	.33	.34	.35	.36
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
4	2½	Calc. Thick.	*.26	*.27	.29	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	3½	Calc. Thick.	*.27	*.28	.30	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	5	Calc. Thick.	*.27	.28	.30	.32	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	8	Calc. Thick.	.31	.32	.32	.33	.35	.37	.40
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	12	Calc. Thick.	.32	.33	.35	.36	.37	.39	.40
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	16	Calc. Thick.	.36	.37	.38	.39	.40	.41	.42
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.40	.40	.40	.40	.40	.40	.43
6	2½	Calc. Thick.	*.33	*.34	*.35	.38	.41	.44	.47
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.43	.43	.43	.43	.43	.43	.46
	3½	Calc. Thick.	.32	.33	.35	.38	.41	.44	.47
		Use Thickness Class.	1	1	1	1	1	1	2
		Use Thickness.	.43	.43	.43	.43	.43	.43	.46
	5	Calc. Thick.	.33	.35	.37	.40	.43	.46	.49
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	8	Calc. Thick.	.38	.40	.41	.43	.45	.47	.50
		Use Thickness Class.	1	1	1	1	2	2	3
		Use Thickness.	.43	.43	.43	.43	.46	.46	.50
	12	Calc. Thick.	.42	.43	.45	.47	.48	.50	.53
		Use Thickness Class.	1	1	2	2	3	3	4
		Use Thickness.	.43	.43	.46	.46	.50	.50	.54
	16	Calc. Thick.	.46	.47	.48	.50	.51	.53	.55
		Use Thickness Class.	2	2	3	3	3	4	4
		Use Thickness.	.46	.46	.50	.50	.50	.54	.54

* Asterisks preceding calculated thicknesses indicate that in such cases truck load rather than water hammer was controlling.

TABLE 2A.4 (*cont'd*)

Field Condition D

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
8	2½	Calc. Thick.	*.40	*.42	*.43	.46	.50	.54	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	3½	Calc. Thick.	*.39	*.41	.44	.48	.51	.55	.59
		Use Thickness Class.	1	1	1	2	2	3	4
		Use Thickness.	.46	.46	.46	.50	.50	.54	.58
	5	Calc. Thick.	.42	.44	.46	.49	.53	.56	.60
		Use Thickness Class.	1	1	1	2	3	4	4
		Use Thickness.	.46	.46	.46	.50	.54	.58	.58
	8	Calc. Thick.	.47	.49	.51	.53	.56	.59	.62
		Use Thickness Class.	1	2	2	3	4	4	5
		Use Thickness.	.46	.50	.50	.54	.58	.58	.63
	12	Calc. Thick.	.52	.54	.56	.58	.61	.63	.66
		Use Thickness Class.	3	3	4	4	5	5	6
		Use Thickness.	.54	.54	.58	.58	.63	.63	.68
	16	Calc. Thick.	.57	.59	.61	.63	.65	.68	.70
		Use Thickness Class.	4	4	5	5	5	6	6
		Use Thickness.	.58	.58	.63	.63	.63	.68	.68
10	2½	Calc. Thick.	*.48	*.49	*.51	*.54	.59	.65	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	3½	Calc. Thick.	*.46	*.47	.51	.55	.60	.65	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	5	Calc. Thick.	*.48	.51	.54	.58	.63	.67	.72
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.50	.50	.54	.58	.63	.68	.73
	8	Calc. Thick.	.55	.57	.60	.63	.67	.71	.75
		Use Thickness Class.	2	3	3	4	5	6	6
		Use Thickness.	.54	.58	.58	.63	.68	.73	.73
	12	Calc. Thick.	.62	.64	.67	.69	.72	.76	.80
		Use Thickness Class.	4	4	5	5	6	7	7
		Use Thickness.	.63	.63	.68	.68	.73	.79	.79
	16	Calc. Thick.	.68	.70	.72	.75	.78	.81	.84
		Use Thickness Class.	5	5	6	6	7	7	8
		Use Thickness.	.68	.68	.73	.73	.79	.79	.85
12	2½	Calc. Thick.	*.53	*.55	*.57	.61	.67	.73	.80
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.54	.54	.58	.63	.68	.73	.79
	3½	Calc. Thick.	*.51	*.53	.57	.62	.67	.73	.80
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.54	.54	.58	.63	.68	.73	.79
	5	Calc. Thick.	*.53	.57	.61	.66	.71	.76	.82
		Use Thickness Class.	1	2	3	4	5	6	7
		Use Thickness.	.54	.58	.63	.68	.73	.79	.85
	8	Calc. Thick.	.61	.64	.67	.71	.75	.80	.85
		Use Thickness Class.	3	3	4	5	5	6	7
		Use Thickness.	.63	.63	.68	.73	.73	.79	.85
	12	Calc. Thick.	.70	.72	.75	.79	.82	.87	.92
		Use Thickness Class.	4	5	5	6	7	7	8
		Use Thickness.	.68	.73	.73	.79	.85	.85	.92
	16	Calc. Thick.	.76	.78	.81	.84	.88	.92	.96
		Use Thickness Class.	6	6	6	7	7	8	9
		Use Thickness.	.79	.79	.79	.85	.85	.92	.99

TABLE 2A.4 (*cont'd*)

Field Condition D

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
14	2½	Calc. Thick.	*.58	*.60	*.63	*.67	.75	.82	.90
		Use Thickness Class.	2	2	3	4	5	7	8
		Use Thickness.	.58	.58	.63	.68	.73	.85	.92
	3½	Calc. Thick.	*.57	*.60	.64	.70	.77	.84	.91
		Use Thickness Class.	2	2	3	4	6	7	8
		Use Thickness.	.58	.58	.63	.68	.79	.85	.92
	5	Calc. Thick.	.60	.64	.68	.73	.79	.86	.92
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.58	.63	.68	.73	.79	.85	.92
	8	Calc. Thick.	.70	.73	.77	.81	.86	.91	.97
		Use Thickness Class.	4	5	6	6	7	8	9
		Use Thickness.	.68	.73	.79	.79	.85	.92	.99
	12	Calc. Thick.	.78	.81	.85	.89	.92	.97	1.03
		Use Thickness Class.	6	6	7	8	8	9	10
		Use Thickness.	.79	.79	.85	.92	.92	.99	1.07
	16	Calc. Thick.	.82	.86	.90	.93	.97	1.01	1.06
		Use Thickness Class.	7	7	8	8	9	9	10
		Use Thickness.	.85	.85	.92	.92	.99	.99	1.07
16	2½	Calc. Thick.	*.62	*.65	*.68	*.73	.81	.90	.99
		Use Thickness Class.	2	2	3	4	5	7	8
		Use Thickness.	.63	.63	.68	.73	.79	.92	.99
	3½	Calc. Thick.	*.62	*.65	*.68	.75	.83	.91	.99
		Use Thickness Class.	2	2	3	4	6	7	8
		Use Thickness.	.63	.63	.68	.73	.85	.92	.99
	5	Calc. Thick.	*.64	.68	.74	.80	.86	.92	1.00
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.63	.68	.73	.79	.85	.92	.99
	8	Calc. Thick.	.75	.79	.83	.88	.93	.99	1.06
		Use Thickness Class.	4	5	6	6	7	8	9
		Use Thickness.	.73	.79	.85	.85	.92	.99	1.07
	12	Calc. Thick.	.84	.87	.91	.95	1.00	1.06	1.12
		Use Thickness Class.	6	6	7	7	8	9	10
		Use Thickness.	.85	.85	.92	.92	.99	1.07	1.16
	16	Calc. Thick.	.88	.91	.95	1.00	1.04	1.10	1.15
		Use Thickness Class.	6	7	7	8	9	9	10
		Use Thickness.	.85	.92	.92	.99	1.07	1.07	1.16
18	2½	Calc. Thick.	*.67	*.70	*.74	*.79	.89	.98	1.08
		Use Thickness Class.	2	2	3	4	6	7	8
		Use Thickness.	.68	.68	.73	.79	.92	.99	1.07
	3½	Calc. Thick.	*.66	*.69	.74	.82	.91	1.00	1.09
		Use Thickness Class.	2	2	3	5	6	7	8
		Use Thickness.	.68	.68	.73	.85	.92	.99	1.07
	5	Calc. Thick.	.70	.74	.80	.87	.95	1.03	1.10
		Use Thickness Class.	2	3	4	5	6	8	8
		Use Thickness.	.68	.73	.79	.85	.92	1.07	1.07
	8	Calc. Thick.	.81	.85	.90	.96	1.02	1.09	1.17
		Use Thickness Class.	4	5	6	7	7	8	9
		Use Thickness.	.79	.85	.92	.99	.99	1.07	1.16
	12	Calc. Thick.	.89	.93	.98	1.03	1.08	1.15	1.22
		Use Thickness Class.	6	6	7	8	8	9	10
		Use Thickness.	.92	.92	.99	1.07	1.07	1.16	1.25
	16	Calc. Thick.	.94	.98	1.03	1.08	1.15	1.20	1.27
		Use Thickness Class.	6	7	8	8	9	9	10
		Use Thickness.	.92	.99	1.07	1.07	1.16	1.16	1.25

TABLE 2A.4 (*cont'd*)

Field Condition D

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
20	2½	Calc. Thick.	*.71	*.75	*.79	*.85	.95	1.05	1.16
		Use Thickness Class.	2	3	3	4	6	7	8
		Use Thickness.	.71	.77	.77	.83	.97	1.05	1.13
	3½	Calc. Thick.	*.71	*.75	*.79	.87	.97	1.07	1.19
		Use Thickness Class.	2	3	3	5	6	7	9
		Use Thickness.	.71	.77	.77	.90	.97	1.05	1.22
	5	Calc. Thick.	*.75	.80	.86	.93	1.02	1.11	1.21
		Use Thickness Class.	3	4	4	5	7	8	9
		Use Thickness.	.77	.83	.83	.90	1.05	1.13	1.22
	8	Calc. Thick.	.85	.90	.96	1.02	1.09	1.17	1.26
		Use Thickness Class.	4	5	6	7	8	8	9
		Use Thickness.	.83	.90	.97	1.05	1.13	1.13	1.22
	12	Calc. Thick.	.94	.99	1.04	1.09	1.15	1.23	1.31
		Use Thickness Class.	6	6	7	8	8	9	10
		Use Thickness.	.97	.97	1.05	1.13	1.13	1.22	1.32
	16	Calc. Thick.	1.00	1.04	1.09	1.14	1.21	1.27	1.35
		Use Thickness Class.	6	7	8	8	9	10	10
		Use Thickness.	.97	1.05	1.13	1.13	1.22	1.32	1.32
24	2½	Calc. Thick.	*.79	*.83	*.88	.96	1.08	1.21	1.35
		Use Thickness Class.	2	3	3	4	6	7	9
		Use Thickness.	.80	.86	.86	.93	1.08	1.17	1.36
	3½	Calc. Thick.	*.78	*.83	*.88	.99	1.11	1.24	1.36
		Use Thickness Class.	2	3	3	5	6	8	9
		Use Thickness.	.80	.86	.86	1.00	1.08	1.26	1.36
	5	Calc. Thick.	*.84	.90	.97	1.06	1.16	1.28	1.39
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.86	.93	1.00	1.08	1.17	1.26	1.36
	8	Calc. Thick.	.92	.99	1.06	1.14	1.22	1.33	1.44
		Use Thickness Class.	4	5	6	7	8	9	10
		Use Thickness.	.93	1.00	1.08	1.17	1.26	1.36	1.47
	12	Calc. Thick.	1.04	1.10	1.16	1.23	1.31	1.40	1.50
		Use Thickness Class.	6	6	7	8	9	9	10
		Use Thickness.	1.08	1.08	1.17	1.26	1.36	1.36	1.47
	16	Calc. Thick.	1.11	1.16	1.22	1.28	1.36	1.45	1.54
		Use Thickness Class.	6	7	8	8	9	10	11
		Use Thickness.	1.08	1.17	1.26	1.26	1.36	1.47	1.59
30	2½	Calc. Thick.	*.91	*.97	*1.04	1.17	1.32	1.48	1.64
		Use Thickness Class.	2	2	3	5	6	8	9
		Use Thickness.	.94	.94	1.02	1.19	1.29	1.50	1.62
	3½	Calc. Thick.	*.91	*.97	1.06	1.20	1.34	1.50	1.66
		Use Thickness Class.	2	2	4	5	7	8	9
		Use Thickness.	.94	.94	1.10	1.19	1.39	1.50	1.62
	5	Calc. Thick.	*.97	1.05	1.15	1.27	1.39	1.53	1.68
		Use Thickness Class.	2	3	5	6	7	8	9
		Use Thickness.	.94	1.02	1.19	1.29	1.39	1.50	1.62
	8	Calc. Thick.	1.09	1.17	1.26	1.35	1.47	1.60	1.73
		Use Thickness Class.	4	5	6	7	8	9	10
		Use Thickness.	1.10	1.19	1.29	1.39	1.50	1.62	1.75
	12	Calc. Thick.	1.22	1.29	1.37	1.45	1.56	1.68	1.81
		Use Thickness Class.	5	6	7	8	9	9	10
		Use Thickness.	1.19	1.29	1.39	1.50	1.62	1.62	1.75
	16	Calc. Thick.	1.30	1.37	1.45	1.53	1.63	1.74	1.85
		Use Thickness Class.	6	7	8	8	9	10	11
		Use Thickness.	1.29	1.39	1.50	1.50	1.62	1.75	1.89

TABLE 2A.4 (*cont'd*)

Field Condition D

S = 11,000 lb. per sq. in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
36	2½	Calc. Thick.	*1.01	*1.09	*1.18	1.33	1.53	1.73	1.92
		Use Thickness Class.	2	3	4	5	7	9	10
		Use Thickness.	1.05	1.13	1.22	1.32	1.54	1.79	1.93
	3½	Calc. Thick.	*1.01	*1.09	1.20	1.36	1.54	1.73	1.92
		Use Thickness Class.	2	3	4	5	7	9	10
		Use Thickness.	1.05	1.13	1.22	1.32	1.54	1.79	1.93
	5	Calc. Thick.	*1.08	1.16	1.28	1.43	1.60	1.78	1.98
		Use Thickness Class.	2	3	5	6	8	9	10
		Use Thickness.	1.05	1.13	1.32	1.43	1.66	1.79	1.93
	8	Calc. Thick.	1.23	1.31	1.42	1.54	1.69	1.84	2.03
		Use Thickness Class.	4	5	6	7	8	9	11
		Use Thickness.	1.22	1.32	1.43	1.54	1.66	1.79	2.08
	12	Calc. Thick.	1.37	1.45	1.55	1.66	1.78	1.93	2.09
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.32	1.43	1.54	1.66	1.79	1.93	2.08
	16	Calc. Thick.	1.47	1.55	1.64	1.75	1.87	2.00	2.14
		Use Thickness Class.	6	7	8	9	10	10	11
		Use Thickness.	1.43	1.54	1.66	1.79	1.93	1.93	2.08
42	2½	Calc. Thick.	*1.12	*1.21	*1.31	1.50	1.72	1.95	2.20
		Use Thickness Class.	2	3	4	5	7	9	10
		Use Thickness.	1.16	1.25	1.35	1.46	1.71	2.00	2.16
	3½	Calc. Thick.	*1.12	*1.21	1.34	1.53	1.74	1.97	2.22
		Use Thickness Class.	2	3	4	6	7	9	10
		Use Thickness.	1.16	1.25	1.35	1.58	1.71	2.00	2.16
	5	Calc. Thick.	*1.21	1.30	1.44	1.61	1.80	2.01	2.24
		Use Thickness Class.	3	4	5	6	8	9	10
		Use Thickness.	1.25	1.35	1.46	1.58	1.85	2.00	2.16
	8	Calc. Thick.	1.35	1.46	1.58	1.73	1.90	2.08	2.28
		Use Thickness Class.	4	5	6	7	8	10	11
		Use Thickness.	1.35	1.46	1.58	1.71	1.85	2.16	2.33
	12	Calc. Thick.	1.51	1.61	1.72	1.85	2.01	2.19	2.36
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.46	1.58	1.71	1.85	2.00	2.16	2.33
	16	Calc. Thick.	1.63	1.73	1.84	1.96	2.12	2.27	2.44
		Use Thickness Class.	6	7	8	9	10	11	12
		Use Thickness.	1.58	1.71	1.85	2.00	2.16	2.33	2.52
48	2½	Calc. Thick.	*1.23	*1.33	*1.45	1.68	1.94	2.21	2.48
		Use Thickness Class.	2	3	4	6	7	9	11
		Use Thickness.	1.27	1.37	1.48	1.73	1.87	2.18	2.54
	3½	Calc. Thick.	*1.24	*1.33	1.50	1.73	1.97	2.23	2.49
		Use Thickness Class.	2	3	4	6	8	9	11
		Use Thickness.	1.27	1.37	1.48	1.73	2.02	2.18	2.54
	5	Calc. Thick.	*1.33	1.44	1.60	1.80	2.03	2.27	2.53
		Use Thickness Class.	3	4	5	7	8	10	11
		Use Thickness.	1.37	1.48	1.60	1.87	2.02	2.35	2.54
	8	Calc. Thick.	1.48	1.61	1.76	1.93	2.13	2.34	2.58
		Use Thickness Class.	4	5	6	7	9	10	11
		Use Thickness.	1.48	1.60	1.73	1.87	2.18	2.35	2.54
	12	Calc. Thick.	1.68	1.80	1.92	2.08	2.26	2.45	2.67
		Use Thickness Class.	6	7	7	8	9	11	12
		Use Thickness.	1.73	1.87	1.87	2.02	2.18	2.54	2.74
	16	Calc. Thick.	1.82	1.93	2.05	2.21	2.37	2.55	2.74
		Use Thickness Class.	7	7	8	9	10	11	12
		Use Thickness.	1.87	1.87	2.02	2.18	2.35	2.54	2.74

TABLE 2A.4 (*cont'd*)

Field Condition D

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
54	2½	Calc. Thick.	*1.33	*1.44	1.60	1.88	2.18	2.47	2.77
		Use Thickness Class.	1	2	4	6	8	9	11
		Use Thickness.	1.30	1.40	1.63	1.90	2.21	2.39	2.79
	3½	Calc. Thick.	*1.38	*1.48	1.64	1.93	2.20	2.49	2.78
		Use Thickness Class.	2	3	4	6	8	10	11
		Use Thickness.	1.40	1.51	1.63	1.90	2.21	2.58	2.79
	5	Calc. Thick.	*1.43	1.57	1.77	2.00	2.28	2.53	2.81
		Use Thickness Class.	2	4	5	7	8	10	11
		Use Thickness.	1.40	1.63	1.76	2.05	2.21	2.58	2.79
	8	Calc. Thick.	1.63	1.77	1.94	2.15	2.36	2.61	2.88
		Use Thickness Class.	4	5	6	8	9	10	11
		Use Thickness.	1.63	1.76	1.90	2.21	2.39	2.58	2.79
	12	Calc. Thick.	1.85	1.98	2.12	2.31	2.50	2.72	2.98
		Use Thickness Class.	6	7	7	9	10	11	12
		Use Thickness.	1.90	2.05	2.05	2.39	2.58	2.79	3.01
	16	Calc. Thick.	2.01	2.13	2.28	2.43	2.62	2.82	3.05
		Use Thickness Class.	7	8	8	9	10	11	12
		Use Thickness.	2.05	2.21	2.21	2.39	2.58	2.79	3.01
60	2½	Calc. Thick.	*1.43	*1.55	1.75	2.06	2.40	2.73	3.07
		Use Thickness Class.	1	2	4	6	8	10	11
		Use Thickness.	1.39	1.50	1.75	2.04	2.38	2.78	3.00
	3½	Calc. Thick.	*1.48	*1.60	1.81	2.11	2.41	2.73	3.07
		Use Thickness Class.	2	3	4	6	8	10	11
		Use Thickness.	1.50	1.62	1.75	2.04	2.38	2.78	3.00
	5	Calc. Thick.	*1.55	*1.77	1.94	2.19	2.48	2.80	3.12
		Use Thickness Class.	2	4	5	7	9	10	12
		Use Thickness.	1.50	1.75	1.89	2.20	2.57	2.78	3.24
	8	Calc. Thick.	1.77	1.92	2.10	2.33	2.58	2.86	3.17
		Use Thickness Class.	4	5	6	8	9	10	12
		Use Thickness.	1.75	1.89	2.04	2.38	2.57	2.78	3.24
	12	Calc. Thick.	2.00	2.14	2.32	2.51	2.73	2.98	3.28
		Use Thickness Class.	6	7	8	9	10	11	12
		Use Thickness.	2.04	2.20	2.38	2.57	2.78	3.00	3.24
	16	Calc. Thick.	2.16	2.30	2.46	2.65	2.86	3.08	3.34
		Use Thickness Class.	7	8	8	9	10	11	12
		Use Thickness.	2.20	2.38	2.38	2.57	2.78	3.00	3.24

TABLE 2A.5 *

Schedule of Barrel Thicknesses—Field Condition E

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
3	2½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	3½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	5	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	8	Calc. Thick.	.26	.27	.28	.29	.30	.31	.32
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	12	Calc. Thick.	.27	.28	.29	.30	.31	.32	.33
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	16	Calc. Thick.	.30	.30	.31	.32	.33	.34	.35
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
4	2½	Calc. Thick.	.27	.28	.30	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	3½	Calc. Thick.	.27	.28	.30	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	5	Calc. Thick.	.27	.29	.30	.32	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	8	Calc. Thick.	.30	.31	.32	.33	.35	.36	.38
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	12	Calc. Thick.	.31	.32	.33	.35	.36	.38	.40
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	16	Calc. Thick.	.34	.35	.36	.37	.38	.40	.41
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
6	2½	Calc. Thick.	.32	.33	.35	.38	.41	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	3½	Calc. Thick.	.32	.33	.35	.38	.41	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	5	Calc. Thick.	.33	.35	.37	.39	.42	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	8	Calc. Thick.	.36	.38	.40	.42	.44	.47	.49
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	12	Calc. Thick.	.39	.41	.42	.44	.46	.49	.51
		Use Thickness Class.	1	1	1	1	2	3	3
		Use Thickness.	.43	.43	.43	.43	.46	.50	.50
	16	Calc. Thick.	.43	.44	.46	.47	.49	.51	.53
		Use Thickness Class.	1	1	2	2	3	3	4
		Use Thickness.	.43	.43	.46	.46	.50	.50	.54

* Asterisks preceding calculated thicknesses indicate that in such cases truck load rather than water hammer was controlling.

TABLE 2A.5 (*cont'd*)

Field Condition E

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
8	2½	Calc. Thick.	*.36	*.38	.41	.45	.49	.53	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	3½	Calc. Thick.	*.35	*.37	.41	.45	.49	.53	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	5	Calc. Thick.	.38	.41	.44	.47	.50	.55	.59
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	8	Calc. Thick.	.43	.45	.48	.50	.53	.57	.61
		Use Thickness Class.	1	1	2	2	3	4	5
		Use Thickness.	.46	.46	.50	.50	.54	.58	.63
	12	Calc. Thick.	.47	.49	.51	.53	.56	.59	.62
		Use Thickness Class.	1	2	2	3	4	4	5
		Use Thickness.	.46	.50	.50	.54	.58	.58	.63
	16	Calc. Thick.	.50	.52	.54	.57	.59	.62	.65
		Use Thickness Class.	2	3	3	4	4	5	5
		Use Thickness.	.50	.54	.54	.58	.58	.63	.63
10	2½	Calc. Thick.	*.43	*.44	.48	.53	.59	.64	.69
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	3½	Calc. Thick.	.42	.45	.50	.55	.59	.64	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	5	Calc. Thick.	.44	.47	.51	.55	.60	.61	.71
		Use Thickness Class.	1	1	1	2	3	5	6
		Use Thickness.	.50	.50	.50	.54	.58	.68	.73
	8	Calc. Thick.	.50	.52	.55	.59	.63	.68	.72
		Use Thickness Class.	1	2	2	3	4	5	6
		Use Thickness.	.50	.54	.54	.58	.63	.68	.73
	12	Calc. Thick.	.56	.58	.61	.64	.67	.71	.76
		Use Thickness Class.	3	3	4	4	5	6	7
		Use Thickness.	.58	.58	.63	.63	.68	.73	.79
	16	Calc. Thick.	.58	.60	.63	.66	.69	.73	.77
		Use Thickness Class.	3	3	4	5	5	6	7
		Use Thickness.	.58	.58	.63	.68	.68	.73	.79
12	2½	Calc. Thick.	*.47	*.49	.53	.59	.66	.72	.79
		Use Thickness Class.	1	1	1	2	4	5	6
		Use Thickness.	.54	.54	.54	.58	.68	.73	.79
	3½	Calc. Thick.	*.46	.49	.55	.60	.67	.72	.80
		Use Thickness Class.	1	1	1	2	4	5	6
		Use Thickness.	.54	.54	.54	.58	.68	.73	.79
	5	Calc. Thick.	.49	.52	.57	.62	.68	.74	.80
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.54	.54	.58	.63	.68	.73	.79
	8	Calc. Thick.	.55	.59	.63	.67	.71	.77	.83
		Use Thickness Class.	1	2	3	4	5	6	7
		Use Thickness.	.54	.58	.63	.68	.73	.79	.85
	12	Calc. Thick.	.61	.64	.67	.71	.75	.80	.85
		Use Thickness Class.	3	3	4	5	5	6	7
		Use Thickness.	.63	.63	.68	.73	.73	.79	.85
	16	Calc. Thick.	.64	.66	.70	.73	.77	.82	.87
		Use Thickness Class.	3	4	4	5	6	7	7
		Use Thickness.	.63	.68	.68	.73	.79	.85	.85

TABLE 2A.5 (*cont'd*)

Field Condition E

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
14	2½	Calc. Thick.	*.51	*.53	.59	.66	.74	.81	.89
		Use Thickness Class.	1	1	2	4	5	6	8
		Use Thickness.	.54	.54	.58	.68	.73	.79	.92
	3½	Calc. Thick.	*.50	.55	.61	.67	.75	.82	.90
		Use Thickness Class.	1	1	3	4	5	7	8
		Use Thickness.	.54	.54	.63	.68	.73	.85	.92
	5	Calc. Thick.	.54	.58	.64	.70	.76	.83	.91
		Use Thickness Class.	1	2	3	4	6	7	8
		Use Thickness.	.54	.58	.63	.68	.79	.85	.92
	8	Calc. Thick.	.62	.65	.70	.75	.81	.87	.93
		Use Thickness Class.	3	3	4	5	6	7	8
		Use Thickness.	.63	.63	.68	.73	.79	.85	.92
	12	Calc. Thick.	.67	.70	.74	.79	.84	.90	.95
		Use Thickness Class.	4	4	5	6	7	8	8
		Use Thickness.	.68	.68	.73	.79	.85	.92	.92
	16	Calc. Thick.	.70	.73	.77	.81	.86	.92	.97
		Use Thickness Class.	4	5	6	6	7	8	9
		Use Thickness.	.68	.73	.79	.79	.85	.92	.99
16	2½	Calc. Thick.	*.55	*.57	.64	.72	.80	.89	.98
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.58	.58	.63	.73	.79	.92	.99
	3½	Calc. Thick.	*.54	.58	.66	.73	.81	.90	.98
		Use Thickness Class.	1	1	3	4	5	7	8
		Use Thickness.	.58	.58	.68	.73	.79	.92	.99
	5	Calc. Thick.	.58	.63	.69	.76	.83	.91	.99
		Use Thickness Class.	1	2	3	5	6	7	8
		Use Thickness.	.58	.63	.68	.79	.85	.92	.99
	8	Calc. Thick.	.66	.70	.76	.81	.87	.94	1.01
		Use Thickness Class.	3	3	5	5	6	7	8
		Use Thickness.	.68	.68	.79	.79	.85	.92	.99
	12	Calc. Thick.	.72	.76	.80	.85	.91	.98	1.05
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.73	.79	.79	.85	.92	.99	1.07
	16	Calc. Thick.	.76	.79	.83	.88	.94	1.00	1.07
		Use Thickness Class.	5	5	6	6	7	8	9
		Use Thickness.	.79	.79	.85	.85	.92	.99	1.07
18	2½	Calc. Thick.	*.59	*.62	.69	.78	.88	.98	1.09
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.63	.63	.68	.79	.85	.99	1.07
	3½	Calc. Thick.	*.59	.63	.71	.80	.89	.99	1.10
		Use Thickness Class.	1	1	3	4	6	7	8
		Use Thickness.	.63	.63	.73	.79	.92	.99	1.07
	5	Calc. Thick.	.62	.68	.75	.83	.91	1.00	1.11
		Use Thickness Class.	1	2	3	5	6	7	8
		Use Thickness.	.63	.68	.73	.85	.92	.99	1.07
	8	Calc. Thick.	.71	.76	.81	.88	.95	1.03	1.13
		Use Thickness Class.	3	4	4	5	6	7	9
		Use Thickness.	.73	.79	.79	.85	.92	.99	1.16
	12	Calc. Thick.	.77	.82	.87	.93	1.00	1.07	1.15
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.79	.85	.85	.92	.99	1.07	1.16
	16	Calc. Thick.	.81	.86	.91	.96	1.02	1.10	1.18
		Use Thickness Class.	4	5	6	7	7	8	9
		Use Thickness.	.79	.85	.92	.99	.99	1.07	1.16

TABLE 2A.5 (*cont'd*)

Field Condition E

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
20	2½	Calc. Thick.	*.62	*.66	.73	.83	.93	1.05	1.17
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.66	.66	.71	.83	.90	1.05	1.13
	3½	Calc. Thick.	*.62	.67	.76	.85	.95	1.06	1.18
		Use Thickness Class.	1	1	3	4	6	7	9
		Use Thickness.	.66	.66	.77	.83	.97	1.05	1.22
	5	Calc. Thick.	.67	.73	.80	.88	.97	1.08	1.19
		Use Thickness Class.	1	2	4	5	6	7	9
		Use Thickness.	.66	.71	.83	.90	.97	1.05	1.22
	8	Calc. Thick.	.75	.80	.86	.92	1.02	1.10	1.21
		Use Thickness Class.	3	4	4	5	7	8	9
		Use Thickness.	.77	.83	.83	.90	1.05	1.13	1.22
	12	Calc. Thick.	.82	.87	.92	.99	1.06	1.13	1.24
		Use Thickness Class.	4	5	5	6	7	8	9
		Use Thickness.	.83	.90	.90	.97	1.05	1.13	1.22
	16	Calc. Thick.	.87	.91	.97	1.03	1.09	1.18	1.27
		Use Thickness Class.	5	5	6	7	8	9	10
		Use Thickness.	.90	.90	.97	1.05	1.13	1.22	1.32
24	2½	Calc. Thick.	*.70	*.74	.82	.95	1.08	1.22	1.35
		Use Thickness Class.	1	1	2	4	6	8	9
		Use Thickness.	.74	.74	.80	.93	1.08	1.26	1.36
	3½	Calc. Thick.	*.70	.76	.86	.97	1.09	1.23	1.36
		Use Thickness Class.	1	1	3	5	6	8	9
		Use Thickness.	.74	.74	.86	1.00	1.08	1.26	1.36
	5	Calc. Thick.	.75	.82	.91	1.01	1.12	1.24	1.37
		Use Thickness Class.	1	2	4	5	6	8	9
		Use Thickness.	.74	.80	.93	1.00	1.08	1.26	1.36
	8	Calc. Thick.	.84	.90	.98	1.07	1.17	1.27	1.40
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.86	.93	1.00	1.08	1.17	1.26	1.36
	12	Calc. Thick.	.92	.98	1.05	1.13	1.21	1.32	1.43
		Use Thickness Class.	4	5	6	7	7	9	10
		Use Thickness.	.93	1.00	1.08	1.17	1.17	1.36	1.47
	16	Calc. Thick.	.98	1.04	1.10	1.18	1.27	1.36	1.47
		Use Thickness Class.	5	6	6	7	8	9	10
		Use Thickness.	1.00	1.08	1.08	1.17	1.26	1.36	1.47
30	2½	Calc. Thick.	*.83	*.89	.99	1.15	1.30	1.48	1.65
		Use Thickness Class.	1	1	3	5	6	8	9
		Use Thickness.	.87	.87	1.02	1.19	1.29	1.50	1.62
	3½	Calc. Thick.	*.83	*.89	1.03	1.17	1.32	1.49	1.65
		Use Thickness Class.	1	1	3	5	6	8	9
		Use Thickness.	.87	.87	1.02	1.19	1.29	1.50	1.62
	5	Calc. Thick.	.89	.98	1.09	1.22	1.36	1.50	1.67
		Use Thickness Class.	1	3	4	5	7	8	9
		Use Thickness.	.87	1.02	1.10	1.19	1.39	1.50	1.62
	8	Calc. Thick.	1.01	1.08	1.18	1.29	1.42	1.56	1.70
		Use Thickness Class.	3	4	5	6	7	9	10
		Use Thickness.	1.02	1.10	1.19	1.29	1.39	1.62	1.75
	12	Calc. Thick.	1.11	1.18	1.25	1.36	1.48	1.61	1.74
		Use Thickness Class.	4	5	6	7	8	9	10
		Use Thickness.	1.10	1.19	1.29	1.39	1.50	1.62	1.75
	16	Calc. Thick.	1.18	1.24	1.32	1.42	1.53	1.64	1.78
		Use Thickness Class.	5	6	6	7	8	9	10
		Use Thickness.	1.19	1.29	1.29	1.39	1.50	1.62	1.75

TABLE 2A.5 (*cont'd*)

Field Condition E

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
36	2½	Calc. Thick.	*.94	*1.01	1.13	1.32	1.52	1.73	1.92
		Use Thickness Class.	1	2	3	5	7	9	10
		Use Thickness.	.97	1.05	1.13	1.32	1.54	1.79	1.93
	3½	Calc. Thick.	*.94	*1.01	1.18	1.35	1.53	1.73	1.93
		Use Thickness Class.	1	2	4	5	7	9	10
		Use Thickness.	.97	1.05	1.22	1.32	1.54	1.79	1.93
	5	Calc. Thick.	1.03	1.12	1.24	1.40	1.58	1.75	1.93
		Use Thickness Class.	2	3	4	6	7	9	10
		Use Thickness.	1.05	1.13	1.22	1.43	1.54	1.79	1.93
	8	Calc. Thick.	1.13	1.23	1.35	1.47	1.64	1.80	1.96
		Use Thickness Class.	3	4	5	6	8	9	10
		Use Thickness.	1.13	1.22	1.32	1.43	1.66	1.79	1.93
	12	Calc. Thick.	1.27	1.35	1.44	1.57	1.71	1.85	2.05
		Use Thickness Class.	5	5	6	7	8	9	11
		Use Thickness.	1.32	1.32	1.43	1.54	1.66	1.79	2.08
	16	Calc. Thick.	1.34	1.43	1.53	1.64	1.78	1.93	2.10
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.32	1.43	1.54	1.66	1.79	1.93	2.08
42	2½	Calc. Thick.	*1.05	*1.13	1.27	1.48	1.71	1.93	2.23
		Use Thickness Class.	1	2	3	5	7	9	10
		Use Thickness.	1.07	1.16	1.25	1.46	1.71	2.00	2.16
	3½	Calc. Thick.	*1.06	*1.13	1.31	1.50	1.74	1.95	2.24
		Use Thickness Class.	1	2	4	5	7	9	10
		Use Thickness.	1.07	1.16	1.35	1.46	1.71	2.00	2.16
	5	Calc. Thick.	*1.12	1.23	1.38	1.57	1.78	1.98	2.25
		Use Thickness Class.	2	3	4	6	7	9	11
		Use Thickness.	1.16	1.25	1.35	1.58	1.71	2.00	2.33
	8	Calc. Thick.	1.26	1.37	1.50	1.65	1.85	2.05	2.28
		Use Thickness Class.	3	4	5	7	8	9	11
		Use Thickness.	1.25	1.35	1.46	1.71	1.85	2.00	2.33
	12	Calc. Thick.	1.41	1.51	1.63	1.76	1.93	2.10	2.33
		Use Thickness Class.	5	5	6	7	9	10	11
		Use Thickness.	1.46	1.46	1.58	1.71	2.00	2.16	2.33
	16	Calc. Thick.	1.52	1.61	1.73	1.86	2.02	2.18	2.38
		Use Thickness Class.	6	6	7	8	9	10	11
		Use Thickness.	1.58	1.58	1.71	1.85	2.00	2.16	2.33
48	2½	Calc. Thick.	*1.15	*1.25	1.43	1.68	1.94	2.19	2.50
		Use Thickness Class.	1	2	4	6	7	9	11
		Use Thickness.	1.18	1.27	1.48	1.73	1.87	2.18	2.54
	3½	Calc. Thick.	*1.15	1.27	1.47	1.70	1.95	2.20	2.51
		Use Thickness Class.	1	2	4	6	8	9	11
		Use Thickness.	1.18	1.27	1.48	1.73	2.02	2.18	2.54
	5	Calc. Thick.	*1.23	1.38	1.56	1.76	2.00	2.28	2.52
		Use Thickness Class.	2	3	5	6	8	10	11
		Use Thickness.	1.27	1.37	1.60	1.73	2.02	2.35	2.54
	8	Calc. Thick.	1.40	1.53	1.69	1.88	2.08	2.33	2.55
		Use Thickness Class.	3	4	6	7	8	10	11
		Use Thickness.	1.37	1.48	1.73	1.87	2.02	2.35	2.54
	12	Calc. Thick.	1.57	1.68	1.82	1.98	2.18	2.41	2.62
		Use Thickness Class.	5	6	7	8	9	10	11
		Use Thickness.	1.60	1.73	1.87	2.02	2.18	2.35	2.54
	16	Calc. Thick.	1.70	1.80	1.94	2.09	2.28	2.47	2.68
		Use Thickness Class.	6	7	7	8	10	11	12
		Use Thickness.	1.73	1.87	1.87	2.02	2.35	2.54	2.74

TABLE 2A.5 (*cont'd*)

Field Condition E

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
54	2½	Calc. Thick.	*1.26	*1.38	1.58	1.87	2.16	2.47	2.78
		Use Thickness Class.	1	2	4	6	8	9	11
		Use Thickness.	1.30	1.40	1.63	1.90	2.21	2.39	2.79
	3½	Calc. Thick.	*1.29	*1.40	1.62	1.90	2.18	2.48	2.79
		Use Thickness Class.	1	2	4	6	8	9	11
		Use Thickness.	1.30	1.40	1.63	1.90	2.21	2.39	2.79
	5	Calc. Thick.	*1.36	1.51	1.72	1.98	2.20	2.53	2.80
		Use Thickness Class.	2	3	5	7	8	10	11
		Use Thickness.	1.40	1.51	1.76	2.05	2.21	2.58	2.79
	8	Calc. Thick.	1.51	1.68	1.87	2.08	2.33	2.58	2.85
		Use Thickness Class.	3	4	6	7	9	10	11
		Use Thickness.	1.51	1.63	1.90	2.05	2.39	2.58	2.79
	12	Calc. Thick.	1.74	1.87	2.04	2.21	2.43	2.67	2.92
		Use Thickness Class.	5	6	7	8	9	10	12
		Use Thickness.	1.76	1.90	2.05	2.21	2.39	2.58	3.01
	16	Calc. Thick.	1.88	2.01	2.16	2.34	2.53	2.73	2.98
		Use Thickness Class.	6	7	8	9	10	11	12
		Use Thickness.	1.90	2.05	2.21	2.39	2.58	2.79	3.01
60	2½	Calc. Thick.	*1.36	*1.48	1.73	2.04	2.38	2.73	3.08
		Use Thickness Class.	1	2	4	6	8	10	11
		Use Thickness.	1.39	1.50	1.75	2.04	2.38	2.78	3.00
	3½	Calc. Thick.	*1.40	1.53	1.78	2.08	2.39	2.74	3.09
		Use Thickness Class.	1	2	4	6	8	10	11
		Use Thickness.	1.39	1.50	1.75	2.04	2.38	2.78	3.00
	5	Calc. Thick.	*1.47	1.65	1.88	2.15	2.45	2.78	3.10
		Use Thickness Class.	2	3	5	7	8	10	11
		Use Thickness.	1.50	1.62	1.89	2.20	2.38	2.78	3.00
	8	Calc. Thick.	1.68	1.84	2.03	2.28	2.55	2.83	3.15
		Use Thickness Class.	3	5	6	7	9	10	12
		Use Thickness.	1.62	1.89	2.04	2.20	2.57	2.78	3.24
	12	Calc. Thick.	1.90	2.04	2.23	2.43	2.68	2.93	3.23
		Use Thickness Class.	5	6	7	8	10	11	12
		Use Thickness.	1.89	2.04	2.20	2.38	2.78	3.00	3.24
	16	Calc. Thick.	2.07	2.20	2.38	2.56	2.78	3.03	3.30
		Use Thickness Class.	6	7	8	9	10	11	12
		Use Thickness.	2.04	2.20	2.38	2.57	2.78	3.00	3.24

TABLE 2A.6.*

Schedule of Barrel Thicknesses—Field Condition F

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
3	2½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	3½	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	5	Calc. Thick.	*.24	*.25	*.25	*.26	.28	.30	.31
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	8	Calc. Thick.	.25	.26	.26	.27	.29	.31	.32
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	12	Calc. Thick.	.27	.27	.29	.30	.31	.32	.33
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
	16	Calc. Thick.	.29	.30	.30	.31	.32	.33	.34
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.37	.37	.37	.37	.37	.37	.37
4	2½	Calc. Thick.	.27	.28	.30	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	3½	Calc. Thick.	.27	.28	.30	.31	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	5	Calc. Thick.	.27	.29	.30	.32	.33	.35	.37
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	8	Calc. Thick.	.30	.31	.32	.33	.35	.36	.38
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	12	Calc. Thick.	.31	.32	.33	.35	.36	.38	.39
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
	16	Calc. Thick.	.32	.33	.35	.36	.37	.39	.40
		Use Thickness Class.	1	1	1	1	1	1	1
		Use Thickness.	.40	.40	.40	.40	.40	.40	.40
6	2½	Calc. Thick.	.32	.33	.35	.38	.41	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	3½	Calc. Thick.	.32	.33	.35	.38	.41	.43	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	5	Calc. Thick.	.32	.33	.35	.38	.41	.45	.48
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	8	Calc. Thick.	.35	.36	.38	.40	.43	.46	.49
		Use Thickness Class.	1	1	1	1	1	2	3
		Use Thickness.	.43	.43	.43	.43	.43	.46	.50
	12	Calc. Thick.	.38	.40	.41	.43	.46	.48	.51
		Use Thickness Class.	1	1	1	1	2	3	3
		Use Thickness.	.43	.43	.43	.43	.46	.50	.50
	16	Calc. Thick.	.41	.42	.44	.46	.48	.50	.53
		Use Thickness Class.	1	1	1	2	3	3	4
		Use Thickness.	.43	.43	.43	.46	.50	.50	.54

* Asterisks preceding calculated thicknesses indicate that in such cases truck load rather than water hammer was controlling.

TABLE 2A.6 (*cont'd*)

Field Condition F

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
8	2½	Calc. Thick.	.35	.37	.41	.45	.49	.53	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	3½	Calc. Thick.	.35	.37	.41	.45	.49	.53	.58
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	5	Calc. Thick.	.37	.40	.43	.46	.50	.55	.59
		Use Thickness Class.	1	1	1	1	2	3	4
		Use Thickness.	.46	.46	.46	.46	.50	.54	.58
	8	Calc. Thick.	.41	.43	.46	.49	.52	.56	.60
		Use Thickness Class.	1	1	1	2	3	4	4
		Use Thickness.	.46	.46	.46	.50	.54	.58	.58
	12	Calc. Thick.	.45	.47	.50	.52	.55	.58	.62
		Use Thickness Class.	1	1	2	3	3	4	5
		Use Thickness.	.46	.46	.50	.54	.54	.58	.63
	16	Calc. Thick.	.48	.50	.52	.54	.57	.60	.63
		Use Thickness Class.	2	2	3	3	4	4	5
		Use Thickness.	.50	.50	.54	.54	.58	.58	.63
10	2½	Calc. Thick.	.41	.44	.48	.53	.59	.64	.69
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	3½	Calc. Thick.	.41	.44	.49	.53	.58	.64	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	5	Calc. Thick.	.43	.46	.50	.55	.60	.65	.70
		Use Thickness Class.	1	1	1	2	3	4	5
		Use Thickness.	.50	.50	.50	.54	.58	.63	.68
	8	Calc. Thick.	.48	.51	.54	.57	.62	.67	.71
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.50	.50	.54	.58	.63	.68	.73
	12	Calc. Thick.	.52	.55	.58	.61	.65	.69	.73
		Use Thickness Class.	1	2	3	4	4	5	6
		Use Thickness.	.50	.54	.58	.63	.63	.68	.73
	16	Calc. Thick.	.55	.57	.60	.63	.67	.71	.75
		Use Thickness Class.	2	3	3	4	5	6	6
		Use Thickness.	.54	.58	.58	.63	.68	.73	.73
12	2½	Calc. Thick.	*.44	.48	.53	.59	.66	.72	.79
		Use Thickness Class.	1	1	1	2	4	5	6
		Use Thickness.	.54	.54	.54	.58	.68	.73	.79
	3½	Calc. Thick.	.44	.48	.54	.60	.66	.72	.79
		Use Thickness Class.	1	1	1	2	4	5	6
		Use Thickness.	.54	.54	.54	.58	.68	.73	.79
	5	Calc. Thick.	.47	.51	.56	.61	.67	.73	.80
		Use Thickness Class.	1	1	2	3	4	5	6
		Use Thickness.	.54	.54	.58	.63	.68	.73	.79
	8	Calc. Thick.	.53	.56	.60	.65	.70	.76	.81
		Use Thickness Class.	1	2	2	3	4	5	6
		Use Thickness.	.54	.58	.58	.63	.68	.73	.79
	12	Calc. Thick.	.57	.60	.64	.68	.73	.78	.83
		Use Thickness Class.	2	2	3	4	5	6	7
		Use Thickness.	.58	.58	.63	.68	.73	.79	.85
	16	Calc. Thick.	.60	.63	.66	.70	.74	.79	.84
		Use Thickness Class.	2	3	4	4	5	6	7
		Use Thickness.	.58	.63	.68	.68	.73	.79	.85

TABLE 2A.6 (*cont'd*)

Field Condition F

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
14	2½	Calc. Thick.	*.48	.52	.59	.66	.74	.81	.89
		Use Thickness Class.	1	1	2	4	5	6	8
		Use Thickness.	.54	.54	.58	.68	.73	.79	.92
	3½	Calc. Thick.	.48	.54	.60	.66	.74	.82	.90
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.54	.54	.58	.68	.73	.85	.92
	5	Calc. Thick.	.51	.56	.62	.68	.75	.82	.90
		Use Thickness Class.	1	2	3	4	5	7	8
		Use Thickness.	.54	.58	.63	.68	.73	.85	.92
	8	Calc. Thick.	.58	.62	.66	.72	.78	.85	.92
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.58	.63	.68	.73	.79	.85	.92
	12	Calc. Thick.	.63	.66	.71	.76	.81	.87	.93
		Use Thickness Class.	3	4	5	6	6	7	8
		Use Thickness.	.63	.68	.73	.79	.79	.85	.92
	16	Calc. Thick.	.65	.69	.73	.77	.83	.88	.94
		Use Thickness Class.	3	4	5	6	7	7	8
		Use Thickness.	.63	.68	.73	.79	.85	.85	.92
16	2½	Calc. Thick.	*.51	.56	.63	.72	.80	.89	.98
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.58	.58	.63	.73	.79	.92	.99
	3½	Calc. Thick.	.51	.57	.64	.72	.81	.89	.98
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.58	.58	.63	.73	.79	.92	.99
	5	Calc. Thick.	.55	.60	.67	.74	.81	.90	.99
		Use Thickness Class.	1	1	3	4	5	7	8
		Use Thickness.	.58	.58	.68	.73	.79	.92	.99
	8	Calc. Thick.	.62	.66	.72	.78	.85	.92	1.00
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.63	.68	.73	.79	.85	.92	.99
	12	Calc. Thick.	.66	.71	.76	.81	.88	.95	1.01
		Use Thickness Class.	3	4	5	5	6	7	8
		Use Thickness.	.68	.73	.79	.79	.85	.92	.99
	16	Calc. Thick.	.70	.74	.79	.84	.90	.97	1.03
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.68	.73	.79	.85	.92	.99	1.07
18	2½	Calc. Thick.	*.54	.61	.68	.78	.88	.98	1.09
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.63	.63	.68	.79	.85	.99	1.07
	3½	Calc. Thick.	*.54	.61	.70	.78	.88	.98	1.10
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.63	.63	.68	.79	.85	.99	1.07
	5	Calc. Thick.	.60	.66	.72	.81	.90	.99	1.10
		Use Thickness Class.	1	2	3	4	6	7	8
		Use Thickness.	.63	.68	.73	.79	.92	.99	1.07
	8	Calc. Thick.	.66	.71	.77	.85	.92	1.01	1.11
		Use Thickness Class.	2	3	4	5	6	7	8
		Use Thickness.	.68	.73	.79	.85	.92	.99	1.07
	12	Calc. Thick.	.71	.76	.82	.89	.96	1.04	1.13
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.73	.79	.85	.92	.99	1.07	1.16
	16	Calc. Thick.	.75	.80	.85	.91	.98	1.06	1.15
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.73	.79	.85	.92	.99	1.07	1.16

TABLE 2A.6 (*cont'd*)

Field Condition F

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
20	2½	Calc. Thick.	*.57	.62	.72	.82	.93	1.05	1.16
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.66	.66	.71	.83	.90	1.05	1.13
	3½	Calc. Thick.	*.57	.64	.73	.83	.93	1.05	1.17
		Use Thickness Class.	1	1	2	4	5	7	8
		Use Thickness.	.66	.66	.71	.83	.90	1.05	1.13
	5	Calc. Thick.	.62	.69	.77	.86	.96	1.06	1.18
		Use Thickness Class.	1	2	3	4	6	7	9
		Use Thickness.	.66	.71	.77	.83	.97	1.05	1.22
	8	Calc. Thick.	.69	.75	.82	.90	.98	1.08	1.19
		Use Thickness Class.	2	3	4	5	6	7	9
		Use Thickness.	.71	.77	.83	.90	.97	1.05	1.22
	12	Calc. Thick.	.76	.81	.87	.94	1.02	1.10	1.21
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.77	.83	.90	.97	1.05	1.13	1.22
	16	Calc. Thick.	.80	.85	.91	.97	1.05	1.13	1.23
		Use Thickness Class.	4	4	5	6	7	8	9
		Use Thickness.	.83	.83	.90	.97	1.05	1.13	1.22
24	2½	Calc. Thick.	*.64	.71	.82	.95	1.08	1.22	1.35
		Use Thickness Class.	1	1	2	4	6	8	9
		Use Thickness.	.74	.74	.80	.93	1.08	1.26	1.36
	3½	Calc. Thick.	*.64	.71	.83	.96	1.08	1.23	1.36
		Use Thickness Class.	1	1	3	4	6	8	9
		Use Thickness.	.74	.74	.86	.93	1.08	1.26	1.36
	5	Calc. Thick.	.69	.78	.88	.98	1.10	1.24	1.37
		Use Thickness Class.	1	2	3	5	6	8	9
		Use Thickness.	.74	.80	.86	1.00	1.08	1.26	1.36
	8	Calc. Thick.	.76	.84	.92	1.02	1.13	1.26	1.39
		Use Thickness Class.	1	3	4	5	7	8	9
		Use Thickness.	.74	.86	.93	1.00	1.17	1.26	1.36
	12	Calc. Thick.	.84	.91	.98	1.07	1.17	1.28	1.40
		Use Thickness Class.	3	4	5	6	7	8	9
		Use Thickness.	.86	.93	1.00	1.08	1.17	1.26	1.36
	16	Calc. Thick.	.89	.95	1.02	1.11	1.20	1.31	1.42
		Use Thickness Class.	3	4	5	6	7	9	10
		Use Thickness.	.86	.93	1.00	1.08	1.17	1.36	1.47
30	2½	Calc. Thick.	*.74	.83	.98	1.14	1.30	1.48	1.64
		Use Thickness Class.	1	1	3	4	6	8	9
		Use Thickness.	.87	.87	1.02	1.10	1.29	1.50	1.62
	3½	Calc. Thick.	*.74	.87	1.00	1.16	1.31	1.49	1.64
		Use Thickness Class.	1	1	3	5	6	8	9
		Use Thickness.	.87	.87	1.02	1.19	1.29	1.50	1.62
	5	Calc. Thick.	.83	.93	1.05	1.18	1.33	1.50	1.65
		Use Thickness Class.	1	2	3	5	6	8	9
		Use Thickness.	.87	.94	1.02	1.19	1.29	1.50	1.62
	8	Calc. Thick.	.91	1.00	1.10	1.23	1.37	1.52	1.67
		Use Thickness Class.	2	3	4	5	7	8	9
		Use Thickness.	.94	1.02	1.10	1.19	1.39	1.50	1.62
	12	Calc. Thick.	1.00	1.08	1.17	1.28	1.42	1.55	1.70
		Use Thickness Class.	3	4	5	6	7	8	10
		Use Thickness.	1.02	1.10	1.19	1.29	1.39	1.50	1.75
	16	Calc. Thick.	1.04	1.13	1.23	1.33	1.44	1.58	1.73
		Use Thickness Class.	3	4	5	6	7	9	10
		Use Thickness.	1.02	1.10	1.19	1.29	1.39	1.62	1.75

TABLE 2A.6 (*cont'd*)

Field Condition F

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
36	2½	Calc. Thick.	*.83	.93	1.12	1.33	1.52	1.73	1.93
		Use Thickness Class.	1	1	3	5	7	9	10
		Use Thickness.	.97	.97	1.13	1.32	1.54	1.79	1.93
	3½	Calc. Thick.	.86	.98	1.13	1.33	1.53	1.73	1.93
		Use Thickness Class.	1	1	3	5	7	9	10
		Use Thickness.	.97	.97	1.13	1.32	1.54	1.79	1.93
	5	Calc. Thick.	.92	1.03	1.18	1.36	1.53	1.74	1.93
		Use Thickness Class.	1	2	4	5	7	9	10
		Use Thickness.	.97	1.05	1.22	1.32	1.54	1.79	1.93
	8	Calc. Thick.	1.02	1.13	1.26	1.40	1.58	1.76	1.95
		Use Thickness Class.	2	3	4	6	7	9	10
		Use Thickness.	1.05	1.13	1.22	1.43	1.54	1.79	1.93
	12	Calc. Thick.	1.12	1.22	1.33	1.47	1.62	1.80	1.98
		Use Thickness Class.	3	4	5	6	8	9	10
		Use Thickness.	1.13	1.22	1.32	1.43	1.66	1.79	1.93
	16	Calc. Thick.	1.19	1.29	1.40	1.52	1.66	1.83	2.03
		Use Thickness Class.	4	5	6	7	8	9	11
		Use Thickness.	1.22	1.32	1.43	1.54	1.66	1.79	2.08
42	2½	Calc. Thick.	*.89	*1.03	1.24	*1.48	1.70	1.94	2.23
		Use Thickness Class.	1	1	3	5	7	9	10
		Use Thickness.	1.07	1.07	1.25	1.46	1.71	2.00	2.16
	3½	Calc. Thick.	*.92	1.06	1.27	1.48	1.73	1.95	2.23
		Use Thickness Class.	1	1	3	5	7	9	10
		Use Thickness.	1.07	1.07	1.25	1.46	1.71	2.00	2.16
	5	Calc. Thick.	1.01	1.16	1.31	1.51	1.74	1.96	2.24
		Use Thickness Class.	1	2	4	5	7	9	10
		Use Thickness.	1.07	1.16	1.35	1.46	1.71	2.00	2.16
	8	Calc. Thick.	1.12	1.24	1.38	1.57	1.78	1.98	2.25
		Use Thickness Class.	2	3	4	6	8	9	11
		Use Thickness.	1.16	1.25	1.35	1.58	1.85	2.00	2.33
	12	Calc. Thick.	1.23	1.35	1.48	1.65	1.84	2.03	2.27
		Use Thickness Class.	3	4	5	7	8	9	11
		Use Thickness.	1.25	1.35	1.46	1.71	1.85	2.00	2.33
	16	Calc. Thick.	1.32	1.43	1.55	1.70	1.88	2.06	2.30
		Use Thickness Class.	4	5	6	7	8	9	11
		Use Thickness.	1.35	1.46	1.58	1.71	1.85	2.00	2.33
48	2½	Calc. Thick.	*.98	1.18	1.43	1.68	1.93	2.19	2.50
		Use Thickness Class.	1	1	4	6	7	9	11
		Use Thickness.	1.18	1.18	1.48	1.73	1.87	2.18	2.54
	3½	Calc. Thick.	*.98	1.18	1.43	1.68	1.93	2.20	2.50
		Use Thickness Class.	1	1	4	6	7	9	11
		Use Thickness.	1.18	1.18	1.48	1.73	1.87	2.18	2.54
	5	Calc. Thick.	1.12	1.27	1.48	1.71	1.95	2.21	2.51
		Use Thickness Class.	1	2	4	6	8	9	11
		Use Thickness.	1.18	1.27	1.48	1.73	2.02	2.18	2.54
	8	Calc. Thick.	1.23	1.38	1.56	1.76	2.00	2.28	2.53
		Use Thickness Class.	2	3	5	6	8	10	11
		Use Thickness.	1.27	1.37	1.60	1.73	2.02	2.35	2.54
	12	Calc. Thick.	1.36	1.50	1.66	1.83	2.05	2.32	2.55
		Use Thickness Class.	3	4	5	7	8	10	11
		Use Thickness.	1.37	1.48	1.60	1.87	2.02	2.35	2.54
	16	Calc. Thick.	1.46	1.59	1.74	1.91	2.12	2.34	2.58
		Use Thickness Class.	4	5	6	7	9	10	11
		Use Thickness.	1.48	1.60	1.73	1.87	2.18	2.35	2.54

TABLE 2A.6 (*cont'd*)

Field Condition F

S = 11,000 lb. per sq.in. R = 31,000 lb. per sq.in.

NOMINAL DIAM., INCH	DEPTH OF COVER, FEET		INTERNAL PRESSURE—LB. PER SQ.IN.						
			50	100	150	200	250	300	350
			Barrel thicknesses in inches						
54	2½	Calc. Thick.	*1.05	1.28	1.58	1.87	2.16	2.48	2.78
		Use Thickness Class.	1	1	4	6	8	9	11
		Use Thickness.	1.30	1.30	1.63	1.90	2.21	2.39	2.79
	3½	Calc. Thick.	1.10	1.33	1.58	1.87	2.17	2.48	2.78
		Use Thickness Class.	1	1	4	6	8	9	11
		Use Thickness.	1.30	1.30	1.63	1.90	2.21	2.39	2.79
	5	Calc. Thick.	1.20	1.40	1.61	1.90	2.18	2.49	2.79
		Use Thickness Class.	1	2	4	6	8	10	11
		Use Thickness.	1.30	1.40	1.63	1.90	2.21	2.58	2.79
	8	Calc. Thick.	1.36	1.52	1.72	1.97	2.23	2.53	2.82
		Use Thickness Class.	2	3	5	6	8	10	11
		Use Thickness.	1.40	1.51	1.76	1.90	2.21	2.58	2.79
	12	Calc. Thick.	1.49	1.64	1.85	2.05	2.31	2.58	2.84
		Use Thickness Class.	3	4	6	7	9	10	11
		Use Thickness.	1.51	1.63	1.90	2.05	2.39	2.58	2.79
	16	Calc. Thick.	1.61	1.75	1.93	2.13	2.37	2.62	2.88
		Use Thickness Class.	4	5	6	8	9	10	11
		Use Thickness.	1.63	1.76	1.90	2.21	2.39	2.58	2.79
60	2½	Calc. Thick.	*1.13	1.40	1.70	2.03	2.38	2.72	3.08
		Use Thickness Class.	1	1	4	6	8	10	11
		Use Thickness.	1.39	1.39	1.75	2.04	2.38	2.78	3.00
	3½	Calc. Thick.	*1.18	1.43	1.72	2.05	2.39	2.73	3.09
		Use Thickness Class.	1	1	4	6	8	10	11
		Use Thickness.	1.39	1.39	1.75	2.04	2.38	2.78	3.00
	5	Calc. Thick.	1.30	1.53	1.78	2.08	2.43	2.74	3.09
		Use Thickness Class.	1	2	4	6	8	10	11
		Use Thickness.	1.39	1.50	1.75	2.04	2.38	2.78	3.00
	8	Calc. Thick.	1.46	1.66	1.88	2.16	2.47	2.76	3.10
		Use Thickness Class.	2	3	5	7	8	10	11
		Use Thickness.	1.50	1.62	1.89	2.20	2.38	2.78	3.00
	12	Calc. Thick.	1.63	1.80	2.00	2.24	2.53	2.83	3.14
		Use Thickness Class.	3	4	6	7	9	10	12
		Use Thickness.	1.62	1.75	2.04	2.20	2.57	2.78	3.24
	16	Calc. Thick.	1.76	1.92	2.10	2.33	2.58	2.86	3.17
		Use Thickness Class.	4	5	6	8	9	10	12
		Use Thickness.	1.75	1.89	2.04	2.38	2.57	2.78	3.24

ASA
A21.2-1939

American Standard

SPECIFICATIONS

for

CAST IRON PIT CAST PIPE FOR WATER OR OTHER LIQUIDS

Approved by
American Standards Association
December, 1939

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

AMERICAN ENGINEERING AND INDUSTRIAL STANDARDS

Users of this document should make reference to "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe (A.S.A., A21.1–1939) for complete information concerning the conditions which various thicknesses of pipe are designed to meet. The foreword of the Manual also contains a statement regarding the history of the specifications and references to other related documents.

AMERICAN STANDARD SPECIFICATIONS
for
CAST IRON PIT CAST PIPE FOR WATER OR OTHER LIQUIDS

This specification covers cast iron pit cast pipe for water or other liquids. Pit cast pipe are pipe cast vertically with dry sand molds and cores.

Sect. 2-1. Description of Pipe. The pipe shall be made with bell and spigot ends, plain ends or such other type of ends as may be agreed upon at the time of purchase. Pipe with bell and spigot ends shall conform accurately to the dimensions given in Table 1. Pipe with other types of ends shall comply with the dimensions agreed upon but in all other respects shall fulfill the specifications hereinafter given. Pipe shall be straight and shall be true circles in section, with their inner and outer surfaces concentric. They shall be at least 12 ft. in nominal laying length, except as provided for cut pipe in Sect. 2-10.

Sect. 2-2. Casting of Pipe. The pipe shall be cast in dry sand molds in a vertical position. Pipe 16 inches or less in diameter shall be cast with the bell end up or down as specified in the proposals. Pipe 18 inches or more in diameter shall be cast with the bell end down. The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Sect. 2-3. Quality of Iron.

(a) All pipes shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the pipe to be cast, that the iron in the pipe shall be strong, tough, resilient, of even grain and soft enough for satisfactory

drilling and cutting and it shall comply with the physical specifications given in Sect. 2-16, 2-17 and 2-18. The metal shall be remelted in a cupola or other suitable furnace.

(b) The iron in the pipe shall not contain more than 0.90 per cent of phosphorus nor more than 0.10 per cent of sulphur. Samples for chemical analysis shall be taken by drilling completely through from skin to skin each of the acceptance test specimens; but not to exceed three specimens per heat.

Sect. 2-4. Quality of Castings. The pipe shall be smooth, free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Sect. 2-5. Foundry Records.

(a) Casting—A record of the melting and pouring temperatures of the iron shall be furnished the purchaser if requested.

(b) Chemical analyses shall be made by the manufacturer from each heat to determine total carbon, manganese, phosphorus, sulphur and silicon; duplicate copies of test reports shall be furnished the purchaser on request.

Sect. 2-6. Marking Pipe. Every pipe shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4-inch may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

1940	1940	1940
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall have dimensions as indicated below.

Diameters of Pipe, Inches, Inclusive	Height of Letter, Inches	Relief, Inch
3 to 10	$\frac{3}{4}$	$\frac{3}{32}$
12 to 20	$1\frac{1}{4}$	$\frac{3}{32}$
24 & larger	$1\frac{3}{4}$	$\frac{1}{8}$

The weight and the class designation shall be conspicuously painted in white in the inside of each pipe after the coating has become hard.

Sect. 2-7. Inspection by Purchaser.

(a) *Definition of Word "Purchaser."* Wherever the word "Purchaser" is used herein it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

(b) *Power of Purchaser to Inspect.* The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, the pattern work, molding, casting, coating and lining of the pipe. The forms, sizes, uniformity and conditions of all pipe herein referred to shall be subject to his inspection and approval, and he may reject, without subjection to hydrostatic test, any pipe which is not in conformity with the specifications or drawings. Any pipe rejected shall be marked "rejected" and any marks pertaining to the purchaser shall be chipped or erased from such pipe.

(c) *Manufacturer to Furnish Men and Material.* The manufacturer shall provide all tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the pipe at the foundry.

(d) *Report of Purchaser's Inspection.* The purchaser shall make written report daily at the foundry office of all pipe rejected, noting causes for rejection.

Sect. 2-8. Inspection and Certification by Manufacturer. Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made as specified, this statement to contain the results of all specified tests.

Sect. 2-9. Pipe to Be Delivered Sound. All the pipe must be delivered in all respects sound and comformable to these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect, and any defective pipe which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for pipe found to be cracked after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating or lining and no pipe or other material

of any kind shall be placed in the pipe during transportation or at any other time after they have received the coating or lining.

Sect. 2-10. Cut Pipe. Defective spigot ends on pipe may be cut off in a manner which will produce a square end. Cut pipe shall be shipped with plain ends or shall have an iron or steel band shrunk into a groove or welded securely on the pipe, as may be agreed upon at time of purchase. Not more than 8 per cent of the total number of pipe of each size shall be cut, and no cut pipe shall be furnished which is less than 11 ft. 0 in. in laying length, unless it has been used by purchaser's order for strip and ring tests in which case a length of not less than 10 ft. 0 in. shall be accepted.

Sect. 2-11. Tolerances or Maximum Permitted Variations from Standard.

(a) *Tolerances in Diameter of Pipe and Sockets.* Outside diameters of pipe barrels and spigot beads and diameters of sockets shall be kept as nearly as practicable to the specified dimensions. They shall be tested with circular gauges. Tolerances or maximum permitted variations from standard dimensions are listed below:

Nominal Diameter in Inches	Tolerances, Plus and Minus, in Inches, in Outside Diameter of Pipe Barrel and Spigot Bead and in Diameter of Socket Pipe
3 to 16	.06
18, 20 & 24	.08
30, 36 & 42	.10
48	.12
54	.15
60	.15

(b) *Tolerances in Thickness.* The tolerances, or maximum permitted variations from standard in thickness of pipe and in dimensions of bells are listed below:

Nominal Diameter in Inches, inclusive	Tolerance, Plus or Minus, in Inches
3 to 8	.07
10 to 24	.08
30 to 60	.10

Note: In pipe barrel thickness, tolerances .02 inch greater than those listed above shall be permissible over areas not exceeding 8 inches in length in any direction.

(c) *Allowable Percentage of Variation in Weight.* The weight of no single pipe shall be less than the nominal tabulated weight by more than 5% for pipe 16 inches or less in diameter, and 4% for pipe more than 16 inches in diameter. The total excess weight to be paid for on orders of 25 tons or more shall not exceed 2% of the nominal weight, and on orders less than 25 tons shall not exceed 5% of the nominal weight. An order is hereby defined as including all the pipe ordered under the terms of a specific contract or purchase order or a single order placed under the terms of a standing contract.

Sect. 2-12. Cleaning and Inspecting. All pipe shall have gates, fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful surface inspection, a hammer test, and a rolling test, before being coated or lined.

Sect. 2-13. Hydrostatic Test. Each pipe shall be subjected to a hydrostatic proof test. This test may be made either before or after the tar dip or the priming coat for bituminous enamel has been applied but shall be made before the cement mortar lining, bituminous enamel lining, or any other special lining has been applied to pipe for which such a lining is specified.

The pipe shall be under the test pressure for at least one-half minute, and while under pressure shall be subjected to a hammer or shock test. Any pipe showing defects by leaking, sweating, or otherwise, shall be rejected. The test pressures shall be in accordance with the table on the following page.

Sect. 2-14. Weighing. Each length of pipe shall be weighed and the weight plainly marked on the outside or inside of the bell or spigot end. Pipe which is to be lined with cement mortar or coated on the inside or outside, or both, with bituminous enamel or other special material shall be weighed before the application of such a lining or coating. If desired by the purchaser, pipe not lined or coated with cement mortar, bituminous enamel or other special material shall be weighed after delivery and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weigh master. Unless otherwise stated in the contract, a ton shall be 2,000 lb. avoirdupois.

Sect. 2-15. Linings and Exterior Coatings. Any lining or coating which is to be applied to the pipe, shall be specified in the agreement made at time of purchase. Separate specifications for the following linings and coatings have been or will be provided in

TABLE OF PRESSURES FOR HYDROSTATIC TESTS

Nominal Diameter of Pipe, Inches	Barrel Thickness, Inches		Test Pressures, Lb. per sq.in.
	From	To	
3 to 12	All Thicknesses		400
14	.50	.70	300
14	.71	.85	350
14	.86	1.20	450
16	.55	.75	300
16	.76	.95	350
16	.96	1.25	450
18	.60	.80	300
18	.81	1.00	350
18	1.01	1.35	450
20	.65	.85	250
20	.86	1.05	350
20	1.06	1.45	450
24	.70	.90	200
24	.91	1.00	300
24	1.01	1.60	400
30	.85	1.05	200
30	1.06	1.30	300
30	1.31	1.75	400
36	.95	1.15	200
36	1.16	1.45	300
36	1.46	1.95	350
42	1.05	1.35	200
42	1.36	1.60	300
42	1.61	1.75	350
48	1.15	1.50	200
48	1.51	1.90	300
48	1.91	2.05	350
54	1.30	1.55	200
54	1.56	1.80	250
54	1.81	2.05	300
54	2.06	2.25	350
60	1.35	1.75	200
60	1.76	2.05	250
60	2.06	2.30	300
60	2.31	2.40	350

Note: Unless otherwise arranged between the manufacturer and the purchaser, pipe thicker than those listed in the above table shall be tested at the highest pressures listed for the given diameter.

connection with these specifications for pipe:

1. Cement Mortar Lining (A21.4–1939)
2. Coal Tar Dip (in preparation)
3. { Bituminous Enamel Lining
   { Bituminous Enamel Exterior Coating

Sect. 2-16. Tests of Material. The acceptability of iron used in cast iron pipe as regards physical characteristics shall be determined by the testing of bars cast from the same iron as the pipe, or, if specified by the purchaser, by the testing of Talbot strips and/or rings cut from the pipe as described in Sect. 2-18. Such strip and/or ring tests shall be paid for by the purchaser at prices to be agreed upon. In any case the test bars shall be made and tested and results given to the purchaser if requested. The smallest pipe on which ring tests may be required is the 6-inch. The observations and the computed results hereinafter required shall be recorded and if requested reported to the purchaser.

Sect. 2-17. Test Bars.

(a) *Dimensions.* Test bars shall be 2 inches wide, 1 inch thick, and not less than 26 inches long. Individual test bars may vary as much as 2 per cent from standard width, or standard thickness, or both, but the patterns and molding practice shall be such that the errors shall in general not exceed 1 per cent.

(b) *Methods of Casting.* The bars shall be cast vertically in well-faced, dry sand molds provided with suitable pouring basin and mounted on a suitable refractory foundation. Metal for the bars shall be obtained by using a small heated ladle taking its metal from the main ladle from which the pipe is to be poured and after all alloys and other additional metal, except cast iron pipe for cooling, have been added to the main ladle and become melted. The bars shall not be removed from the mold before they have cooled to 500°F.

(c) *When Cast and to What Pipe Applicable.* Except as hereinafter provided for special cases, one pair of test bars of the metal used shall be cast with iron from the first ladle, another pair with iron from the approximately middle ladle, and a third pair with iron from the last ladle of iron taken during a day's run or heat from the cupola in which the iron for the pipe is melted. If the heat lasts for more than 6 hours, then additional pairs of bars shall be cast at approximately uniform intervals so as to give an extra pair of bars for each 3 hours during which the heat lasts in excess of 6 hours.

In case the charging of the cupola is to be changed one or more times during the day's run or heat in order to produce a different iron, the time of taking test bars shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality; and in case such period exceeds four hours additional pairs of bars shall be taken at such times as will provide a pair of bars for each two hours during which this special mixture is used. At least one bar from each pair shall be broken, but the manufacturer shall have the right to break both bars in which case the better bar shall be taken as representative. Bars showing flaws in fracture may be disregarded.

(d) *Test Bar Requirements to Indicate Acceptable Iron; Retests may be made at Contractor's Option using Talbot Strips and/or Rings.* In order that the iron shall be acceptable the average results from the single bars representing the respective pairs of bars cast during the heat or period shall comply with the requirements hereinafter specified and, in addition, no representative bar shall be more than 5 percent below the minimum requirements in either corrected breaking load or corrected deflection. In case the test bars do not measure up to these requirements the manufacturer may make one or more Talbot strip tests and/or ring tests of specimens cut from such of the pipe as may be agreed upon as best representing the iron at the time when the deficient test bars were cast. In the absence of the purchaser the manufacturer may select the pipe from which rings and/or strips shall be cut. The results from these rings and/or strips shall be kept as a foundry record available to any purchaser who requires a report of tests on the 2-inch by 1-inch bars. Any Talbot strip tests or ring tests made under this provision shall be at the expense of the manufacturer. If these supplementary Talbot strip tests and/or ring tests do not meet the requirements, the pipe cast in that heat or period, or such a part thereof as may be agreed to by the purchaser, shall be rejected.

(e) *Method of Testing.* The bars shall be broken as beams by placing them flatwise on supports 24 inches apart and applying the load at the center of the span. The breaking load and the corresponding deflection shall be observed and recorded.

(f) *Correcting Observed Breaking Loads and Deflections.* The bars shall be measured at the point of application of the load and the results corrected to standard 2 inch by 1 inch cross section by the

conventional beam formula as follows:

Corrected breaking load = observed breaking load multiplied by $\frac{2}{bd^2}$

Corrected deflection at breaking = observed deflection at breaking multiplied by d

where b = measured width and

d = measured depth

of the bar at point of application of load

In the formulae above the deflection and all dimensions are in inches.

(g) *Requirements as to Strength and Deflection of 2 inch by 1 inch Bars.* In order to indicate acceptable metal, the corrected breaking loads and deflections of the representative 2 inch by 1 inch test bars for a given heat or period interpreted as provided in paragraph (d) above, shall comply with such of the following tabulated requirements as pertain to the thickness range within which fall the particular pipes which are under consideration.

TABLE OF MINIMUM CORRECTED BREAKING LOADS & DEFLECTIONS

Metal Thickness of Pipe, Inch	Minimum Center Breaking Load, Pounds	Minimum Center Deflection at Breaking, Inch
Below .61	1900	.30 + .0001 (Breaking Load − 1900)
.61 to .90	2000	.30 + .0001 (Breaking Load − 2000)
.91 to 1.60	2200	.30 + .0001 (Breaking Load − 2200)
1.61 to 2.50	2300	.30 + .0001 (Breaking Load − 2300)

Note: For thicknesses exceeding 2.50 inches the form of test specimen and the test requirements shall be as agreed upon in the purchase contract.

Sect. 2-18. Talbot Strip Tests and Ring Tests.

(a) *Dimensions.* Rings shall have a length equal to half the nominal diameter of the pipe unless the diameter exceeds 24 inches, in which case the length of ring shall be 12 inches. Strips shall be not less than 11 inches long and for 24-inch and larger pipe may be cut from the least stressed portions of rings (see Sect. 2-18 (d) after the rings have been broken. The end 2 inches of the pipe shall not be included in ring or strip.

Note: To make both ring and strip tests on a pipe will therefore require at the least (on 6 inch pipe) 16 inches of pipe, at the most (on 20 inch pipe) 23 inches of pipe, and on pipe larger than 20 inches, 14 inches of pipe.

(b) *Method of Sampling.* The purchaser who has expressly specified Talbot strip tests and/or ring tests as acceptance tests of the

pipe may select at random from each run, or heat, one or more pipe from which test specimens are to be cut. In the absence of the purchaser or his representative, the pipe from which test specimens are to be taken may be selected by the manufacturer. If the purchaser should wish to test the uniformity of a run or heat, he may divide it into two or more periods and have a separate set of acceptance tests for pipe in each period.

(c) *Defective Specimens; Retests.* If any test specimen shows defective machining or obvious lack of continuity of metal, it shall be discarded and replaced by another specimen selected by the purchaser. If the test specimens first selected fail to meet the requirements specified hereinafter and the purchaser permits a retest, at least twice the number of specimens that failed shall be selected by the purchaser for retest from a pipe cast in the same run or period. In case a ring from a pipe 24 inches in diameter or larger fails to

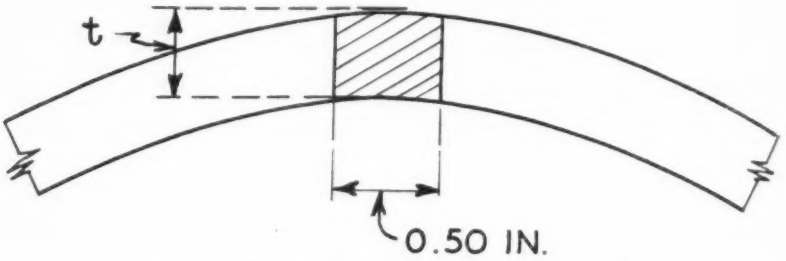


FIG. 1. Position from which Talbot Strip Is Cut

meet specifications, the purchaser may accept strip tests, two specimens to be cut from the failed ring at points of low stress as described in Sect. 2-18 (d). In any case of retest the pipe cast during the run or period shall be acceptable only when all retest specimens meet the requirements. All retests shall be made at the expense of the manufacturer.

(d) *Talbot Strip Tests.* Two Talbot strips shall be machined longitudinally from each pipe selected by the purchaser for testing by this method. If ring tests are also made and the pipe are 24 inches or larger these Talbot strips may be cut from a part of the ring little stressed in the ring test, i.e., near one of the elements marked (a) in Fig. 2. (See Sect. 2-18 (e).) The strips in any case will be in cross section as indicated in Fig. 1, i.e., will have for their width the thickness of the pipe and for their thickness 0.50 inch. Their length will be the length of the ring, 12 inches; or, if

not cut from a ring, at least 11 inches. These strips shall be tested as a beam on supports 10 inches apart with loads applied perpendicularly to the machined faces at two points $3\frac{1}{3}$ inches from the supports. The breaking load and the corresponding deflection shall be observed and recorded.

The strip shall be accurately calipered at point of rupture and the modulus of rupture, R, shall be calculated by the usual beam formula which for this case reduces to the expression:

$$R = \frac{10W}{td^2}$$

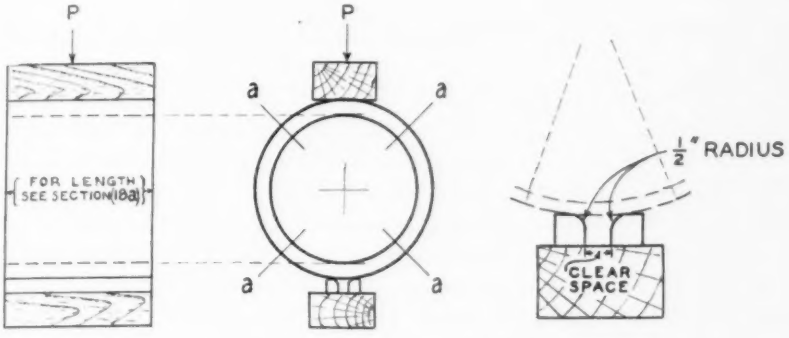


FIG. 2. Assembly for Ring Test

The secant modulus of elasticity, E_s, in lb. per sq.in. shall be computed by the formula:

$$E_s = \frac{213W}{td^3y} = \frac{21.3R}{dy}$$

where R = modulus of rupture, lb. per sq.in.
E_s = secant modulus of elasticity, lb. per sq.in.
W = breaking load, lb.
d = depth of strip in inches (intended to be 0.50 in.)
t = width of strip, inches (pipe thickness)
y = deflection of strip at center at breaking load, inches.

To be acceptable a Talbot strip shall have the modulus of rupture, R, not less than 30,000 lb. per sq.in. and the secant modulus of elasticity, E_s, not more than 10,000,000 lb. per sq.in. If the results from either strip are up to the specifications the test shall be regarded as satisfactory.

(e) *Ring Tests.* Each ring shall be tested by the three-edge-bearing method as indicated in Fig. 2. The lower bearing for the

ring shall consist of two strips with vertical sides having their interior top corners rounded to a radius of approximately $\frac{1}{2}$ inch. The strips shall be of hard wood or of metal. If of metal a piece of leather belting about $\frac{3}{16}$ inch thick shall be laid over them. They shall be straight and shall be securely fastened to a rigid block with their interior vertical faces spaced at a distance apart as given in the following table:

Diam. of Pipe	Clear Space
12-inch and smaller	$\frac{1}{2}$ inch
14-inch to 24-inch inclusive	1 inch
30-inch and larger	2 inch

The upper bearing shall be a rigid wooden block, straight and true from end to end. The upper and lower bearings shall extend the full length of the outside of the ring. The ring shall be placed symmetrically between the two bearings, and the center of application of the load shall be so placed that the vertical deformations at the two ends of the ring shall be equal. If the ring is not uniform in thickness, it shall be so placed that the thick and thin portions are near the ends of the horizontal diameter. A record of the breaking load and the corresponding vertical deformation of each ring tested shall be made. In order to be acceptable the modulus of rupture computed from the formula

$$R = 0.954 \frac{W(d + t)}{bt^2}$$

shall be not less than 31,000 lb. per sq.in., and the secant modulus of elasticity computed from the formula

$$E_s = \frac{0.225\, W(d + t)^3}{bt^3 y} = \frac{0.236\, R(d + t)^2}{ty}$$

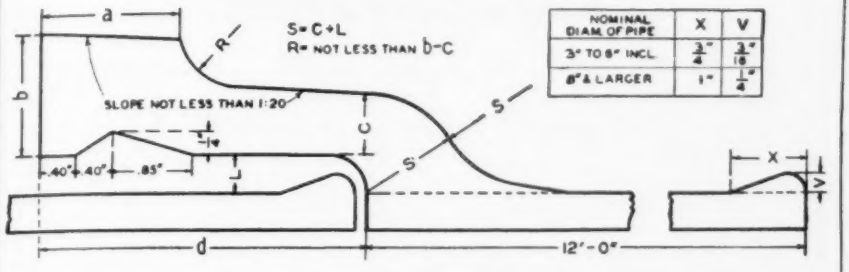
shall not exceed 15,000,000 lb. per sq.in.

b = length of ring, inches
d = average inside diameter of ring, inches
t = average thickness of metal along line of fracture, inches
y = maximum vertical deflection of ring, inches
W = breaking load, in lb.
R = modulus of rupture, lb. per sq.in.
E_s = secant modulus of elasticity, lb. per sq.in.

The modulus of elasticity shall not be determined in rings from pipe less than 12 inches in diameter.

Table No. 1

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS and OUTSIDE DIAMETERS of PIT CAST PIPE also WEIGHTS OF BELLS AND OF SPIGOT BEADS



NOMINAL DIAM. OF PIPE	X	V
3" TO 6" INCL.	1/4"	1/16"
8" & LARGER	1"	1/4"

Nominal Diam.	Thickness of pipe From	Thickness of pipe To	Out-Side Diam. of Pipe	DIMENSIONS OF BELLS: Diam. of Socket	Thickness of Joint L	Depth of Socket d	a	b	c	Wt. of Bell	Wt. of Spigot Bead
3	.37	.45	3.80	4.60	.40	3.50	1.25	1.30	.65	19	.3
	.46	.53	3.96	4.76	.40	3.50	1.25	1.30	.65	20	.3
4	.40	.45	4.80	5.60	.40	3.50	1.50	1.30	.65	23	.3
	.46	.55	5.00	5.80	.40	3.50	1.50	1.30	.65	24	.4
6	.43	.50	6.90	7.70	.40	3.50	1.50	1.40	.70	33	.5
	.51	.60	7.10	7.90	.40	3.50	1.50	1.40	.70	34	.5
	.61	.66	7.22	8.02	.40	4.00	1.50	1.75	.75	56	.9
	.67	.74	7.38	8.18	.40	4.00	1.50	1.85	.85	62	.9
8	.46	.57	9.05	9.85	.40	4.00	1.50	1.50	.75	48	1.1
	.58	.70	9.30	10.10	.40	4.00	1.50	1.50	.75	49	1.2
	.71	.76	9.42	10.22	.40	4.00	1.50	1.85	.85	75	1.2
	.77	.85	9.60	10.40	.40	4.00	1.50	1.95	.95	84	1.2
10	.50	.60	11.10	11.90	.40	4.00	1.50	1.50	.75	58	1.4
	.61	.75	11.40	12.20	.40	4.00	1.50	1.60	.80	64	1.4
	.76	.85	11.60	12.40	.40	4.50	1.75	1.95	.95	99	1.4
	.86	.97	11.84	12.64	.40	4.50	1.75	2.05	1.05	110	1.5
12	.54	.65	13.20	14.00	.40	4.00	1.50	1.60	.80	72	1.6
	.66	.80	13.50	14.30	.40	4.00	1.50	1.70	.85	78	1.7
	.81	.94	13.78	14.58	.40	4.50	1.75	2.05	1.05	125	1.7
	.95	1.09	14.08	14.88	.40	4.50	1.75	2.20	1.20	144	1.7
14	.54	.62	15.30	16.10	.40	4.00	1.50	1.70	.85	88	1.9
	.63	.87	15.65	16.45	.40	4.00	1.50	1.80	.90	96	1.9
	.88	1.04	15.98	16.78	.40	4.50	2.00	2.15	1.15	148	2.0
	1.05	1.21	16.32	17.12	.40	4.50	2.00	2.35	1.35	183	2.0
16	.58	.67	17.40	18.40	.50	4.00	1.75	1.80	.90	114	2.1
	.68	.95	17.80	18.80	.50	4.00	1.75	1.90	1.00	128	2.2
	.96	1.13	18.16	18.96	.40	4.50	2.00	2.30	1.25	180	2.2
	1.14	1.32	18.54	19.34	.40	4.50	2.00	2.55	1.45	224	2.3
18	.63	.72	19.50	20.50	.50	4.00	1.75	1.90	.95	133	2.4
	.73	1.01	19.92	20.92	.50	4.00	1.75	2.10	1.05	154	2.4
	1.02	1.22	20.34	21.14	.40	4.50	2.25	2.45	1.40	222	2.5
	1.23	1.44	20.78	21.58	.40	4.50	2.25	2.75	1.65	283	2.5

All dimensions given in inches. All weights given in pounds.

Table No. 1 (continued)

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS and OUTSIDE DIAMETERS of PIT CAST PIPE also WEIGHTS OF BELLS AND OF SPIGOT BEADS

Nominal Diam.	Thickness of pipe		Out-Side Diam. of Pipe	DIMENSIONS OF BELLS						Wt. of Bell	Wt. of Spigot Bead
	From	To		Diam. of Socket	Thickness of Joint L	Depth of Socket d	a	b	c		
20	.66	.82	21.60	22.60	.50	4.00	1.75	2.00	1.00	156	2.6
	.83	1.08	22.06	23.06	.50	4.00	1.75	2.30	1.15	189	2.7
	1.09	1.32	22.54	23.34	.40	4.50	2.25	2.55	1.50	260	2.8
	1.33	1.56	23.02	23.82	.40	4.50	2.25	2.85	1.75	326	2.8
24	.74	.92	25.80	26.80	.50	4.00	2.00	2.10	1.05	199	3.2
	.93	1.21	26.32	27.32	.50	4.00	2.00	2.50	1.25	250	3.2
	1.22	1.50	26.90	27.90	.50	5.00	2.25	2.75	1.70	349	3.3
	1.51	1.93	27.76	28.56	.40	5.00	2.25	3.15	1.95	489	3.4
30	.87	.92	31.74	32.74	.50	4.50	2.00	2.30	1.15	296	3.9
	.93	1.05	32.00	33.00	.50	4.50	2.00	2.30	1.15	298	3.9
	1.06	1.18	32.40	33.40	.50	4.50	2.00	2.60	1.32	351	4.0
	1.19	1.42	32.74	33.74	.50	4.50	2.00	3.00	1.50	416	4.0
	1.43	1.60	33.10	34.10	.50	5.00	2.25	3.25	1.80	557	4.0
	1.61	1.78	33.46	34.46	.50	5.00	2.25	3.50	2.00	626	4.1
36	.97	1.03	37.96	38.96	.50	4.50	2.00	2.50	1.25	383	4.6
	1.04	1.20	38.30	39.30	.50	4.50	2.00	2.80	1.40	446	4.7
	1.21	1.40	38.70	39.70	.50	4.50	2.00	3.10	1.60	512	4.7
	1.41	1.63	39.16	40.16	.50	4.50	2.00	3.40	1.80	586	4.8
	1.64	1.85	39.60	40.60	.50	5.00	2.25	3.70	2.05	770	4.8
	1.86	2.07	40.04	41.04	.50	5.00	2.25	4.00	2.30	876	4.9
42	1.07	1.15	44.20	45.20	.50	5.00	2.00	2.80	1.40	539	5.4
	1.16	1.30	44.50	45.50	.50	5.00	2.00	3.00	1.50	586	5.4
	1.31	1.57	45.10	46.10	.50	5.00	2.00	3.40	1.75	701	5.5
	1.58	1.84	45.58	46.58	.50	5.00	2.00	3.80	1.95	805	5.8
48	1.18	1.30	50.50	51.50	.50	5.00	2.00	3.00	1.50	660	6.1
	1.31	1.45	50.80	51.80	.50	5.00	2.00	3.30	1.65	745	6.2
	1.46	1.72	51.40	52.40	.50	5.00	2.00	3.80	1.95	900	6.2
	1.73	2.04	51.98	52.98	.50	5.00	2.00	4.20	2.20	1046	6.3
54	1.30	1.38	56.66	57.66	.50	5.50	2.25	3.20	1.60	855	6.9
	1.39	1.60	57.10	58.10	.50	5.50	2.25	3.60	1.80	993	6.9
	1.61	1.89	57.80	58.80	.50	5.50	2.25	4.00	2.15	1189	7.0
	1.90	2.25	58.40	59.40	.50	5.50	2.25	4.40	2.45	1391	7.1
60	1.39	1.45	62.80	63.80	.50	5.50	2.25	3.40	1.70	1021	7.6
	1.46	1.75	63.40	64.40	.50	5.50	2.25	3.70	1.90	1145	7.7
	1.76	2.15	64.20	65.20	.50	5.50	2.25	4.20	2.25	1393	7.8
	2.16	2.46	64.82	65.82	.50	5.50	2.25	4.70	2.60	1647	7.9

All dimensions given in inches. All weights given in pounds.

NOTE: Pipe for pressures greater than 200 pounds per square inch may be supplied with double lead groove if desired.

Table 2

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIT CAST PIPE

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bell	Wt. Based on 12 Ft. Length*	
							Per Length	Avg. Per Foot
1	2	3	4	5	6	7	8	9
3	1	.37	3.80	3.06	12.4	19	170	14.2
	2	.40	3.80	3.00	13.3	19	180	15.0
	3	.43	3.80	2.94	14.2	19	190	15.8
	4	.46	3.96	3.04	15.8	20	210	17.5
	5	.50	3.96	2.96	17.0	20	225	18.8
4	1	.40	4.80	4.00	17.3	23	230	19.2
	2	.43	4.80	3.94	18.4	23	245	20.4
	3	.46	5.00	4.08	20.5	24	270	22.5
	4	.50	5.00	4.00	22.1	24	290	24.2
	5	.54	5.00	3.92	23.6	24	310	25.8
6	1	.43	6.90	6.04	27.3	33	360	30.0
	2	.46	6.90	5.98	29.0	33	380	31.7
	3	.50	6.90	5.90	31.4	33	410	34.2
	4	.54	7.10	6.02	34.7	34	450	37.5
	5	.58	7.10	5.94	37.1	34	480	40.0
	6	.63	7.22	5.96	40.7	56	545	45.4
	7	.68	7.38	6.02	44.7	62	600	50.0
	8	.73	7.38	5.92	47.6	62	635	52.9
8	1	.46	9.05	8.13	38.7	48	515	42.9
	2	.50	9.05	8.05	41.9	48	550	45.8
	3	.54	9.05	7.97	45.0	48	590	49.2
	4	.58	9.30	8.14	49.6	49	645	53.8
	5	.63	9.30	8.04	53.5	49	690	57.5
	6	.68	9.30	7.94	57.5	49	740	61.7
	7	.73	9.42	7.96	62.2	75	825	68.8
	8	.79	9.60	8.02	68.2	84	905	75.4
	9	.85	9.60	7.90	72.9	84	960	80.0
10	1	.50	11.10	10.10	52.0	58	685	57.1
	2	.54	11.10	10.02	55.9	58	730	60.8
	3	.58	11.10	9.94	59.8	58	775	64.6
	4	.63	11.40	10.14	66.5	64	865	72.1
	5	.68	11.40	10.04	71.5	64	925	77.1
	6	.73	11.40	9.94	76.4	64	980	81.7
	7	.79	11.60	10.02	83.7	99	1105	92.1
	8	.85	11.60	9.90	89.6	99	1175	97.9
	9	.92	11.84	10.00	98.5	110	1295	107.9
12	1	.54	13.20	12.12	67.0	72	880	73.3
	2	.58	13.20	12.04	71.8	72	935	77.9
	3	.63	13.20	11.94	77.6	72	1005	83.8
	4	.68	13.50	12.14	85.5	78	1105	92.1
	5	.73	13.50	12.04	91.4	78	1175	97.9
	6	.79	13.50	11.92	98.4	78	1260	105.0
	7	.85	13.78	12.08	107.7	125	1420	118.3
	8	.92	13.78	11.94	116.0	125	1520	126.7
	9	.99	14.08	12.10	127.0	144	1670	139.2
	10	1.07	14.08	11.94	136.4	144	1785	148.8
14	1	.54	15.30	14.22	78.1	88	1025	85.4
	2	.58	15.30	14.14	83.7	88	1095	91.3
	3	.63	15.65	14.39	92.8	96	1210	100.8
	4	.68	15.65	14.29	99.8	96	1295	107.9
	5	.73	15.65	14.19	106.8	96	1380	115.0
	6	.79	15.65	14.07	115.1	96	1480	123.3
	7	.85	15.65	13.95	123.3	96	1580	131.7
	8	.92	15.98	14.14	135.8	148	1780	148.3
	9	.99	15.98	14.00	145.5	148	1895	157.9

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table 2 (continued)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIT CAST PIPE

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bell	Wt. Based on 12 Ft. Length*	
							Per Length	Avg. Per Foot
1	2	3	4	5	6	7	8	9
14	10	1.07	16.32	14.18	160.0	183	2105	175.4
	11	1.16	16.32	14.00	172.4	183	2255	187.9
16	1	.58	17.40	16.24	95.6	114	1265	105.4
	2	.63	17.40	16.14	103.6	114	1360	113.3
	3	.68	17.80	16.44	114.1	128	1500	125.0
	4	.73	17.80	16.34	122.1	128	1595	132.9
	5	.79	17.80	16.22	131.7	128	1710	142.5
	6	.85	17.80	16.10	141.2	128	1825	152.1
	7	.92	17.80	15.96	152.2	128	1955	162.9
	8	.99	18.16	16.18	166.6	180	2180	181.7
	9	1.07	18.16	16.02	179.2	180	2335	194.6
	10	1.16	18.54	16.22	197.6	224	2600	216.7
	11	1.25	18.54	16.04	211.8	224	2770	230.8
18	1	.63	19.50	18.24	116.5	133	1535	127.9
	2	.68	19.50	18.14	125.4	133	1640	136.7
	3	.73	19.92	18.46	137.3	154	1805	150.4
	4	.79	19.92	18.34	148.1	154	1935	161.3
	5	.85	19.92	18.22	158.9	154	2065	172.1
	6	.92	19.92	18.08	171.3	154	2210	184.2
	7	.99	19.92	17.94	183.7	154	2360	196.7
	8	1.07	20.34	18.20	202.1	222	2650	220.8
	9	1.16	20.34	18.02	218.1	222	2840	236.7
	10	1.25	20.78	18.28	239.3	283	3155	262.9
	11	1.35	20.78	18.08	257.1	283	3370	280.8
20	1	.66	21.60	20.28	135.5	156	1785	148.8
	2	.71	21.60	20.18	145.4	156	1905	158.8
	3	.77	21.60	20.06	157.2	156	2045	170.4
	4	.83	22.06	20.40	172.7	189	2265	188.8
	5	.90	22.06	20.26	186.7	189	2430	202.5
	6	.97	22.06	20.12	200.5	189	2600	216.7
	7	1.05	22.06	19.96	216.2	189	2785	232.1
	8	1.13	22.54	20.28	237.1	260	3110	259.2
	9	1.22	22.54	20.10	255.0	260	3325	277.1
	10	1.32	22.54	19.90	274.6	260	3560	296.7
	11	1.43	23.02	20.16	302.6	326	3960	330.0
24	1	.74	25.80	24.32	181.8	199	2385	198.8
	2	.80	25.80	24.20	196.0	199	2555	212.9
	3	.86	25.80	24.08	210.2	199	2725	227.1
	4	.93	26.32	24.46	231.5	250	3030	252.5
	5	1.00	26.32	24.32	248.2	250	3230	269.2
	6	1.08	26.32	24.16	267.2	250	3460	288.3
	7	1.17	26.32	23.98	288.4	250	3715	309.6
	8	1.26	26.90	24.38	316.7	349	4155	346.2
	9	1.36	26.90	24.18	340.5	349	4440	370.0
	10	1.47	26.90	23.96	366.4	349	4750	395.8
	11	1.59	27.76	24.58	407.9	489	5385	448.8
	12	1.72	27.76	24.32	439.0	489	5760	480.0
	13	1.86	27.76	24.04	472.2	489	6160	513.3
30	1	.87	31.74	30.00	263.3	296	3460	288.3
	2	.94	32.00	30.12	286.2	298	3735	311.3
	3	1.02	32.00	29.96	309.7	298	4020	335.0
	4	1.10	32.40	30.20	337.5	351	4405	367.1
	5	1.19	32.74	30.36	368.0	416	4835	402.9
	6	1.29	32.74	30.16	397.7	416	5190	432.5
	7	1.39	32.74	29.96	427.1	416	5545	462.1

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table 2 (continued)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIT CAST PIPE

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bell	Wt. Based on 12 Ft. Length*	
							Per Length	Avg. Per Foot
1	2	3	4	5	6	7	8	9
30	8	1.50	33.10	30.10	464.6	557	6135	511.3
	9	1.62	33.46	30.22	505.6	626	6695	557.9
	10	1.75	33.46	29.96	543.9	626	7155	596.3
36	1	.97	37.96	36.02	351.7	383	4610	384.2
	2	1.05	38.30	36.20	383.4	446	5050	420.8
	3	1.13	38.30	36.04	411.7	446	5390	449.2
	4	1.22	38.70	36.26	448.2	512	5895	491.3
	5	1.32	38.70	36.06	483.6	512	6320	526.7
	6	1.43	39.16	36.30	528.9	586	6940	578.3
	7	1.54	39.16	36.08	567.9	586	7405	617.1
	8	1.66	39.60	36.28	617.3	770	8180	681.7
	9	1.79	39.60	36.02	663.4	770	8735	727.9
	10	1.93	40.04	36.18	720.9	876	9530	794.2
42	1	1.07	44.20	42.06	452.3	539	5970	497.5
	2	1.16	44.50	42.18	492.8	586	6505	542.1
	3	1.25	44.50	42.00	529.9	586	6950	579.2
	4	1.35	45.10	42.40	578.9	701	7655	637.9
	5	1.46	45.10	42.18	624.5	701	8200	683.3
	6	1.58	45.58	42.42	681.4	805	8990	749.2
	7	1.71	45.58	42.16	735.3	805	9635	802.9
48	1	1.18	50.50	48.14	570.4	660	7510	625.8
	2	1.27	50.50	47.96	612.8	660	8020	668.3
	3	1.37	50.80	48.06	663.8	745	8715	726.3
	4	1.48	51.40	48.44	724.2	900	9595	799.6
	5	1.60	51.40	48.20	781.0	900	10280	856.7
	6	1.73	51.98	48.52	852.1	1046	11280	940.0
	7	1.87	51.98	48.24	918.5	1046	12075	1006.3
	8	2.02	51.98	47.94	989.2	1046	12925	1077.1
54	1	1.30	56.66	54.06	705.4	855	9325	777.1
	2	1.40	57.10	54.30	764.3	993	10170	847.5
	3	1.51	57.10	54.08	822.8	993	10875	906.3
	4	1.63	57.80	54.54	897.4	1189	11965	997.1
	5	1.76	57.80	54.28	966.8	1189	12800	1066.7
	6	1.90	58.40	54.60	1052.2	1391	14025	1168.8
	7	2.05	58.40	54.30	1132.3	1391	14985	1248.8
	8	2.21	58.40	53.98	1217.2	1391	16005	1333.8
60	1	1.39	62.80	60.02	836.7	1021	11070	922.5
	2	1.50	63.40	60.40	910.1	1145	12075	1006.3
	3	1.62	63.40	60.16	981.0	1145	12925	1077.1
	4	1.75	63.40	59.90	1057.5	1145	13845	1153.8
	5	1.89	64.20	60.42	1154.3	1393	15250	1270.9
	6	2.04	64.20	60.12	1242.9	1393	16315	1359.6
	7	2.20	64.82	60.42	1350.3	1647	17860	1488.3
	8	2.38	64.82	60.06	1456.6	1647	19135	1594.6

NOTE: When pipe is to be cement lined, patterns and cores giving larger outside and inside diameter without change of thickness will be used if ordered.

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table No. 3

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON PIT CAST PIPE

NOTE: These weights are for Pipe used under normal conditions, i. e., 5 feet of cover, flat bottom trench and tamped backfill.

	CLASS 50			CLASS 100			CLASS 150			CLASS 200		
	50 Lb. Pressure			100 Lb. Pressure			150 Lb. Pressure			200 Lb. Pressure		
	115 Feet Head			231 Feet Head			346 Feet Head			462 Feet Head		
		Wt Based on 12 Ft. Lgh.*			Wt. Based on 12 Ft. Lgh.*			Wt. Based on 12 Ft. Lgh.*			Wt. Based on 12 Ft. Lgh.*	
Size Inches	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length
3	.37	14.2	170	.37	14.2	170	.37	14.2	170	.37	14.2	170
4	.40	19.2	230	.40	19.2	230	.40	19.2	230	.40	19.2	230
6	.43	30.0	360	.43	30.0	360	.43	30.0	360	.43	30.0	360
8	.46	42.9	515	.46	42.9	515	.46	42.9	515	.46	42.9	515
10	.50	57.1	685	.50	57.1	685	.54	60.8	730	.58	64.6	775
12	.54	73.3	880	.54	73.3	880	.58	77.9	935	.63	83.8	1005
14	.54	85.4	1025	.58	91.3	1095	.63	100.8	1210	.68	107.9	1295
16	.58	105.4	1265	.63	113.3	1360	.68	125.0	1500	.79	142.5	1710
18	.63	127.9	1535	.68	136.7	1640	.73	150.4	1805	.85	172.1	2065
20	.66	148.8	1785	.71	158.8	1905	.83	188.8	2265	.90	202.5	2430
24	.74	198.8	2385	.80	212.9	2555	.93	252.5	3030	1.00	269.2	3230
30	.87	288.3	3460	.94	311.3	3735	1.10	367.1	4405	1.19	402.9	4835
36	.97	384.2	4610	1.05	420.8	5050	1.22	491.3	5895	1.43	578.3	6940
42	1.07	497.5	5970	1.25	579.2	6950	1.35	637.9	7655	1.58	749.2	8990
48	1.18	625.8	7510	1.37	726.3	8715	1.48	799.6	9595	1.73	940.0	11280
54	1.30	777.1	9325	1.51	906.3	10875	1.63	997.1	11965	1.90	1168.8	14025
60	1.39	922.5	11070	1.62	1077.1	12925	1.89	1270.9	15250	2.20	1488.3	17860

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table No. 3 (Continued)

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON PIT CAST PIPE

NOTE: These weights are for Pipe used under normal conditions.
i. e., 5 feet of cover, flat bottom trench and tamped backfill.

	CLASS 250			CLASS 300			CLASS 350		
	250 Lb. Pressure			300 Lb. Pressure			350 Lb. Pressure		
	577 Feet Head			693 Feet Head			808 Feet Head		
		Wt. Based on 12 Ft. Lgh.*			Wt. Based on 12 Ft. Lgh.*			Wt. Based on 12 Ft. Lgh.*	
Size Inches	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length
3	.37	14.2	170	.37	14.2	170	.37	14.2	170
4	.40	19.2	230	.40	19.2	230	.40	19.2	230
6	.43	30.0	360	.46	31.7	380	.50	34.2	410
8	.50	45.8	550	.54	49.2	590	.58	53.8	645
10	.63	72.1	865	.68	77.1	925	.73	81.7	980
12	.68	92.1	1105	.73	97.9	1175	.79	105.0	1260
14	.79	123.3	1480	.85	131.7	1580	.92	148.3	1780
16	.85	152.1	1825	.92	162.9	1955	.99	181.7	2180
18	.92	184.2	2210	.99	196.7	2360	1.07	220.8	2650
20	.97	216.7	2600	1.05	232.1	2785	1.22	277.1	3325
24	1.08	288.3	3460	1.26	346.2	4155	1.36	370.0	4440
30	1.39	462.1	5545	1.50	511.3	6135	1.62	557.9	6695
36	1.54	617.1	7405	1.79	727.9	8735	1.93	794.2	9530
42	1.71	802.9	9635						
48	2.02	1077.1	12925						
54	2.21	1333.8	16005						
60	2.38	1594.6	19135						

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table No. 4

STANDARD THICKNESSES OF CAST IRON PIT CAST PIPE

Thickness in Inches. Working Pressure in Pounds per Square Inch.
Thicknesses Include Allowances for Water Hammer,
Foundry Practice and Corrosion

Laying Condition A—Flat Bottom Trench, Untamped Backfill
Laying Condition B—Flat Bottom Trench, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ FEET OF COVER				5 FEET OF COVER				8 FEET OF COVER			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
3	50	.37	.37	.37	.37	.37	.37	.37	.37	.37	.37	.43	.37
	100	.37	.37	.37	.37	.37	.37	.37	.37	.37	.37	.43	.37
	150	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.43	.37
	200	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.43	.37
	250	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.46	.37
	300	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.46	.37
	350	.37	.37	.40	.37	.37	.37	.40	.37	.37	.37	.46	.37
4	50	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	100	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	150	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	200	.40	.40	.43	.40	.40	.40	.43	.40	.40	.40	.50	.40
	250	.40	.40	.43	.40	.40	.40	.46	.40	.40	.40	.50	.40
	300	.40	.40	.43	.40	.40	.40	.46	.40	.40	.40	.54	.40
	350	.40	.40	.46	.40	.40	.40	.46	.40	.40	.40	.54	.40
6	50	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.58	.43
	100	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.58	.43
	150	.43	.43	.50	.43	.43	.43	.50	.43	.43	.43	.58	.43
	200	.43	.43	.50	.43	.43	.43	.54	.43	.43	.43	.58	.43
	250	.43	.43	.50	.43	.43	.43	.54	.43	.46	.46	.63	.46
	300	.46	.43	.54	.43	.46	.46	.54	.46	.50	.46	.63	.46
	350	.50	.50	.54	.46	.50	.50	.58	.50	.50	.50	.63	.50
8	50	.46	.46	.54	.46	.46	.46	.54	.46	.46	.46	.63	.46
	100	.46	.46	.54	.46	.46	.46	.54	.46	.46	.46	.63	.50
	150	.46	.46	.58	.46	.46	.46	.58	.46	.50	.50	.68	.50
	200	.46	.46	.58	.50	.50	.46	.58	.50	.54	.50	.68	.54
	250	.50	.50	.63	.50	.54	.50	.63	.54	.54	.54	.68	.58
	300	.54	.54	.63	.54	.58	.54	.63	.58	.58	.58	.73	.58
	350	.58	.58	.63	.58	.58	.58	.68	.58	.63	.63	.73	.63
10	50	.50	.50	.58	.50	.50	.50	.58	.50	.54	.50	.68	.54
	100	.50	.50	.58	.50	.50	.50	.63	.50	.58	.54	.73	.58
	150	.50	.50	.58	.50	.54	.54	.63	.54	.58	.58	.73	.58
	200	.54	.54	.63	.54	.58	.58	.68	.58	.63	.58	.79	.63
	250	.58	.58	.63	.58	.63	.63	.68	.63	.68	.63	.79	.68
	300	.63	.63	.68	.63	.68	.68	.73	.68	.68	.68	.79	.73
	350	.68	.68	.73	.68	.73	.73	.79	.73	.73	.73	.85	.73
12	50	.54	.54	.58	.54	.54	.54	.63	.54	.58	.58	.73	.63
	100	.54	.54	.63	.54	.54	.54	.63	.58	.63	.58	.79	.63
	150	.58	.54	.63	.58	.58	.58	.68	.63	.68	.63	.79	.68
	200	.63	.58	.68	.63	.63	.63	.73	.68	.68	.68	.85	.73
	250	.68	.68	.73	.68	.68	.68	.79	.73	.73	.73	.85	.73
	300	.73	.73	.79	.73	.73	.73	.79	.79	.79	.79	.92	.79
	350	.79	.79	.85	.79	.79	.79	.85	.85	.85	.85	.92	.85
14	50	.54	.54	.63	.58	.58	.54	.68	.58	.68	.63	.79	.68
	100	.58	.54	.68	.58	.63	.58	.73	.63	.68	.68	.85	.73
	150	.63	.63	.68	.63	.68	.63	.73	.68	.73	.73	.85	.79
	200	.68	.68	.73	.68	.73	.68	.79	.73	.79	.79	.92	.79
	250	.79	.73	.79	.79	.79	.79	.85	.79	.85	.79	.92	.85
	300	.85	.85	.85	.85	.85	.85	.92	.85	.92	.85	.99	.92
	350	.92	.92	.92	.92	.92	.92	.99	.92	.99	.92	1.07	.99

Table No. 4—Continued

Size Inches	Working Pressure	3½ FEET OF COVER				5 FEET OF COVER				8 FEET OF COVER			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
16	50	.58	.58	.68	.63	.63	.58	.73	.63	.73	.68	.85	.73
	100	.63	.58	.73	.63	.68	.63	.73	.68	.73	.73	.85	.79
	150	.68	.68	.73	.68	.73	.68	.79	.73	.79	.79	.92	.85
	200	.73	.73	.79	.73	.79	.79	.85	.79	.85	.79	.92	.85
	250	.79	.79	.85	.85	.85	.85	.92	.85	.92	.85	.99	.92
	300	.92	.92	.92	.92	.92	.92	.99	.92	.99	.92	1.07	.99
	350	.99	.99	.99	.99	.99	.99	1.07	.99	1.07	.99	1.16	1.07
18	50	.63	.63	.73	.68	.68	.63	.79	.68	.79	.73	.85	.79
	100	.68	.63	.73	.68	.73	.68	.79	.73	.85	.79	.92	.85
	150	.73	.73	.79	.73	.79	.73	.85	.79	.85	.85	.99	.92
	200	.79	.79	.85	.85	.85	.85	.92	.85	.92	.85	.99	.99
	250	.92	.92	.92	.92	.92	.92	.99	.92	.99	.99	1.07	.99
	300	.99	.99	.99	.99	.99	.99	1.07	1.07	1.07	1.07	1.16	1.07
	350	1.07	1.07	1.07	1.07	1.07	1.07	1.16	1.07	1.16	1.16	1.25	1.16
20	50	.66	.66	.77	.71	.71	.66	.83	.77	.83	.77	.90	.83
	100	.71	.66	.83	.77	.77	.71	.83	.83	.83	.83	.97	.90
	150	.77	.77	.83	.77	.83	.83	.90	.83	.90	.90	1.05	.97
	200	.83	.83	.90	.90	.90	.90	.97	.90	.97	.97	1.05	1.05
	250	.97	.97	.97	.97	.97	.97	1.05	1.05	1.05	1.05	1.13	1.13
	300	1.05	1.05	1.05	1.05	1.13	1.05	1.13	1.13	1.13	1.13	1.22	1.13
	350	1.22	1.13	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.32	1.22
24	50	.74	.74	.86	.80	.80	.74	.86	.86	.93	.86	1.00	.93
	100	.80	.74	.86	.86	.86	.80	.93	.93	1.00	.93	1.08	1.00
	150	.86	.86	.93	.86	.93	.93	1.00	1.00	1.08	1.00	1.08	1.08
	200	1.00	1.00	1.00	1.00	1.08	1.00	1.08	1.08	1.17	1.08	1.17	1.17
	250	1.08	1.08	1.17	1.08	1.17	1.08	1.17	1.17	1.26	1.17	1.26	1.26
	300	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.36	1.26	1.36	1.36
	350	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.47	1.36	1.47	1.47
30	50	.94	.87	1.02	.94	.94	.87	1.02	.94	1.10	1.02	1.19	1.10
	100	.94	.87	1.02	.94	1.02	.94	1.10	1.02	1.19	1.10	1.29	1.19
	150	1.10	1.02	1.10	1.10	1.19	1.10	1.19	1.19	1.29	1.19	1.39	1.29
	200	1.19	1.19	1.19	1.19	1.29	1.19	1.29	1.29	1.39	1.29	1.39	1.39
	250	1.29	1.29	1.39	1.39	1.39	1.39	1.50	1.39	1.50	1.39	1.50	1.50
	300	1.50	1.50	1.50	1.50	1.50	1.50	1.62	1.50	1.62	1.50	1.62	1.62
	350	1.62	1.62	1.62	1.62	1.62	1.62	1.75	1.62	1.75	1.75	1.75	1.75
36	50	1.05	.97	1.13	1.05	1.05	.97	1.22	1.05	1.22	1.13	1.32	1.22
	100	1.13	.97	1.22	1.13	1.22	1.05	1.22	1.13	1.32	1.22	1.43	1.32
	150	1.22	1.13	1.22	1.22	1.32	1.22	1.32	1.32	1.43	1.32	1.54	1.43
	200	1.32	1.32	1.43	1.32	1.43	1.43	1.43	1.43	1.54	1.43	1.66	1.54
	250	1.54	1.54	1.54	1.54	1.66	1.54	1.66	1.66	1.66	1.66	1.79	1.66
	300	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.93	1.79
	350	1.93	1.93	1.93	1.93	1.93	1.93	2.08	1.93	2.08	1.93	2.08	2.08
42	50	1.16	1.07	1.25	1.16	1.25	1.07	1.35	1.25	1.35	1.25	1.46	1.35
	100	1.25	1.07	1.35	1.25	1.35	1.25	1.35	1.35	1.46	1.35	1.58	1.46
	150	1.35	1.25	1.46	1.35	1.46	1.35	1.46	1.46	1.58	1.46	1.71	1.58
	200	1.58	1.46	1.58	1.58	1.58	1.58	1.71	1.58	1.71	1.58	1.85	1.71
	250	1.71	1.71	1.85	1.71	1.85	1.71	1.85	1.85	1.85	1.85	2.00	1.85
48	50	1.27	1.18	1.37	1.27	1.37	1.18	1.48	1.37	1.60	1.37	1.60	1.48
	100	1.37	1.27	1.48	1.37	1.48	1.37	1.60	1.48	1.73	1.48	1.73	1.60
	150	1.48	1.48	1.60	1.48	1.60	1.48	1.73	1.60	1.87	1.60	1.87	1.73
	200	1.73	1.73	1.73	1.73	1.87	1.73	1.87	1.87	2.02	1.87	2.02	1.87
	250	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.18	2.02	2.18	2.18
54	50	1.40	1.30	1.51	1.40	1.51	1.30	1.63	1.40	1.63	1.51	1.76	1.63
	100	1.51	1.40	1.63	1.51	1.63	1.51	1.76	1.63	1.90	1.63	1.90	1.76
	150	1.63	1.63	1.76	1.63	1.76	1.63	1.90	1.76	2.05	1.76	2.05	1.90
	200	1.90	1.90	2.05	1.90	2.05	1.90	2.05	2.05	2.21	2.05	2.21	2.21
	250	2.21	2.21	2.21	2.21	2.21	2.21	2.39	2.21	2.39	2.21	2.39	2.39
60	50	1.50	1.39	1.62	1.50	1.62	1.39	1.75	1.50	1.89	1.62	1.89	1.75
	100	1.62	1.50	1.75	1.62	1.75	1.62	1.89	1.75	2.04	1.75	2.04	1.89
	150	1.89	1.75	1.89	1.75	2.04	1.89	2.04	1.89	2.20	2.04	2.20	2.04
	200	2.04	2.04	2.20	2.04	2.20	2.20	2.20	2.20	2.38	2.20	2.38	2.38
	250	2.38	2.38	2.38	2.38	2.57	2.38	2.57	2.57	2.57	2.57	2.78	2.57

ASA
A21.4-1939

American Standard

SPECIFICATIONS

for

CEMENT MORTAR LINING FOR CAST IRON PIPE AND FITTINGS

Approved by
American Standards Association
December, 1939

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

AMERICAN ENGINEERING AND INDUSTRIAL STANDARDS

FOREWORD

This specification provides alternative procedures in the case of certain details with respect to which practice is not standardized. The purchaser, when inviting bids, should specify his requirements, if any, with respect to the following details which, unless so specified, will be at the option of the manufacturer:

Sect. 4–10. Whether linings shall have tapered ends or be of full thickness to the ends.

Sect. 4–14. Whether coal-tar outside coating is required. If required, and unless a hot-coal-tar-dip coating is specified, the manufacturer has the option of applying either the specification hot-coal-tar-dip coating or two coats of the specification coal-tar paint.

Sect 4–15. Whether whitewash outside coating is required, and for pipes of what diameters. If not specified the manufacturer has the option of whitewashing or not at his discretion.

Sect. 4–16. Whether bituminous seal coat is required.

AMERICAN STANDARD SPECIFICATIONS
for
CEMENT MORTAR LINING
FOR CAST IRON PIPE AND FITTINGS

Sect. 4-1. Portland Cement

Portland cement shall meet all the requirements of Standard Specifications for Portland Cement of the American Society for Testing Materials, A.S.T.M. Designation: C 9, of latest revision.

Sect. 4-2. Sand

Sand shall consist of hard, strong, durable, uncoated, silicious particles. Under the colorimetric test for organic impurities it shall not produce a color darker than the standard, unless it is shown by adequate tests that the impurities causing the color are not harmful to the strength or other specified properties of the finished lining. It shall lose not more than 3 per cent in the decantation test, not more than 1 per cent on ignition, and not more than 4 per cent in boiling hydrochloric acid. The sand shall be well graded so as to produce a lining as nearly as practicable of maximum density and minimum water absorption consistent with the proportion of cement and the lining methods used, with workability of the mortar and with the other specified properties of the lining; provided that, when tested with standard sieves, it shall meet the following requirements: (1)*

	Per cent
Total passing sieve having a clear opening of the size nearest to one-half the specified minimum thickness of lining	100
Passing No. 100 sieve, not more than	5

* Numbers in parenthesis such as that above refer to notes following this standard.

Sect. 4-3. Accepted Specifications

The specified tests of sand shall be made in accordance with the Standard Methods of the American Society for Testing Materials, and of the American Foundrymen's Association, of latest revision, as follows:

Colorimetric Test: Standard Method of Test for Organic Impurities in Sands for Concrete, A.S.T.M. Designation C40.

Standard Method of Decantation Test for Sand and other Fine Aggregates, A.S.T.M. Designation D136.

Ignition Test: Testing and Grading of Foundry Sand, American Foundrymen's Assn., 1931, p. 94, 25 gram sample, flat porcelain dish.

Solubility in hydrochloric acid—Standard Method of Testing Bituminous Mastics, Grouts, and like Mixtures, A.S.T.M. Designation D147.

Sect. 4-4. Water

Water for tempering the mortar and for curing the lining shall be potable water, as defined in Appendix I, Section 3 of the 1925 U. S. Treasury "Drinking Water Standards."

Sect. 4-5. Mortar

The mortar shall be an intimate and thorough mixture of portland cement, sand and water of the qualities specified, and shall contain no other ingredient; except that, subject to the approval of the purchaser, other hydraulic cements producing lining having lower water-solubility, less shrinkage or other advantages may be substituted for portland cement in whole or in part, other ingredients may be incorporated in the mortar, and/or the sand omitted. Portland cement mortar for linings not exceeding one-quarter inch in minimum thickness shall contain not less than one part of cement to one part of dry sand by volume. (1) (2)

Sect. 4-6. Preparation of Pipe and Fittings for Lining

All pipes and fittings shall be thoroughly cleaned and surfaces to be lined shall be free from harmful amounts of blacking, grease, dirt, loose sand, rust, slag, soda or other flux, and from tar or other coating, and shall be entirely free from sharp projections of iron which might reduce the thickness of the lining. Required hydrostatic tests shall be made before lining.

Sect. 4-7. Method of Applying Cement Mortar Linings

The waterway surfaces of pipes and fittings shall be completely covered with as nearly as practicable a uniform thickness of the specified mortar entirely free from holidays or visible bubbles of air and thoroughly compacted throughout. Straight pipes shall be lined by the centrifugal process, combining high speed spinning and vibration, or by some other process producing linings which are equal to such centrifugal linings in accuracy of surface contour, smoothness of surface texture, density, low water absorption, and freedom from shrinkage cracks and loose spots. Fittings shall be lined by such process as will produce linings equal, as nearly as practicable, in the above enumerated respects to the linings of straight pipes. Defective linings which have set shall not be patched.

Sect. 4-8. Bell to be Cleaned

All mortar shall be removed from the joint surface of the bell.

Sect. 4-9. Work to be Protected

The work of lining the pipes and fittings shall be done in a building where the product shall be protected from the direct rays of the sun, and from extreme weather conditions, such as frost, rain, etc. The product shall not be put on the yard until the cement has set sufficiently to avoid injury or damage thereto.

Sect. 4-10. Thickness of Lining

The thickness of linings for pipes and fittings shall be nowhere less than the following for the respective diameters: 4 to 12 inches, $\frac{1}{8}$ inch; 14 to 24 inches, $\frac{3}{16}$ inch; 30 to 48 inches, $\frac{1}{4}$ inch. Linings shall taper at the ends, or shall be of full thickness to the end of the spigot and to the seat of the bell, as specified. When tapered linings are furnished the length of the taper from the end of the spigot and from the seat of the bell to lining of the full specified thickness shall not exceed sixteen times the specified thickness of lining. A plus tolerance of $\frac{1}{8}$-inch, but no more, shall be permitted on all sizes of pipe and $\frac{1}{4}$-inch, but no more, on all sizes and patterns of fittings. Linings of greater thickness will be furnished when specified.

Sect. 4-11. Determination of Thickness

The thickness of lining may be determined by means of spear measurement, using a hardened steel point not larger than $\frac{1}{16}$ inch in diameter. The inspector shall pierce the lining immediately after it is placed in the pipe, and before the mortar has set, at four dia-

metrically opposite points of the pipe at bell and spigot ends, making two sets of measurements at each end. The first set shall not be more than 4 inches from the respective ends of the pipe and the second set shall be made as far into the interior of the pipe as can readily be reached without injuring the lining.

Sect. 4-12. Curing

All parts of the lining shall be kept constantly damp for at least 42 hours after the lining is placed and as much longer as may be necessary to control separation and cracking. No pipe or fittings shall be shipped until the lining is thoroughly set and hard.

Sect. 4-13. The Finished Lining

The linings of both pipes and fittings, after curing and drying shall meet the following requirements:

(a) *Surface and contour.* The lining shall have a hard, smooth surface and shall be free from noticeable ridges, corrugations, elevations and depressions. The linings of pipes shall be cylindrical; the linings of fittings shall be as nearly as practicable of uniform thickness throughout and shall afford smooth waterways.

(b) *Water absorption.* When tested for water absorption in accordance with Standard Specifications for Cement Concrete Sewer Pipe, A.S.T.M. Designation: C-14, of latest revision, the lining shall show an absorption not exceeding 17 per cent of its dry weight. Samples for this test may be from linings placed for this purpose in the bell, provided that such linings are of the same thickness and mix, placed and compacted at the same time and by the same methods, and subjected to the same curing as the linings of the waterways. Samples at time of tests shall be not more than 30 days older than the most recently placed of the linings in the shipment or order which they represent. (3)

(c) *Cracks and loose spots.* Pipe showing three or more loose spots measuring 12 inches or more in diameter, or three or more shrinkage cracks over 9 inches in length, or any cracks standing open perceptibly, shall be rejected. Surface crazing shall not be cause for rejection.

Sect. 4-14. Bituminous Outside Coatings*

Pipe and fittings for which an outside coal-tar coating is called for, shall be coated hot or cold as specified. Pipes and fittings for which a hot coal-tar coating, or coal-tar dip coating is specified shall be coated hot, before lining, on the outside only, as specified in the Proposed American Standard for Coal-Tar-Dip Coating for Cast Iron Pipe and Fittings.† Pipe and fittings for which a cold coal-tar paint or coating is specified shall receive two coats of an approved coal-tar pitch paint complying in quality and application with the paint described in the same specification. If not specified by the purchaser, the choice of a hot or cold coal-tar coating shall be at the option of the manufacturer.

Sect. 4-15. Whitewash

Unless otherwise specified, whitewashing of the outside surfaces of cement mortar lined pipes and fittings shall be at the option of the manufacturer. If so specified all cement-mortar lined pipes and fittings either of certain sizes or of all sizes shall be coated, after lining and before being exposed to the sun, on all exterior surfaces with an opaque coat of tenacious and weather-resistant whitewash. Whitewashed surfaces which may become damaged or blackened with tar, paint, or otherwise shall be rewhitewashed before shipment.

Sect. 4-16. Bituminous Seal Coat §

When a bituminous seal coat is specified all exposed surfaces of the mortar lining shall, when sufficiently dry, and not less than 66 hours after placing the lining, be given a full coat, without pin holes, blisters or holidays, by brushing, spraying or dipping, or other suitable means, of a water proof asphalt or coal-tar paint which, after drying 48 hours, shall have no deleterious effect upon the quality, color, taste, or odor of potable water which has been standing for 48 hours in the pipe (6). The paint shall adhere tenaciously to the mortar lining at all points. The painted pipe, when tested with distilled water in accordance with Section 4–17, shall not impart to the water more than 25 parts per million of hardness, as determined by the soap test, nor more than 25 parts per million of total alkalinity nor any caustic alkalinity.

Sect. 4-17. Testing of the Sample

Except as another form of specimen and test is agreed upon by purchaser and manufacturer, the sample shall be a 6-inch length of

* See note 4.

† Not completed in December, 1939

§ See note 5.

6- or 8-inch pipe, lathe-cut at both ends. The specimen shall be cut from a pipe whose lining is of the same age and which has been lined, cured and seal-coated in all respects like the product which it represents, the seal-coat being applied 48 hours prior to the test. With this form of specimen the test shall be made by bedding the specimen on end in a shallow pan of melted paraffin, allowing the paraffin to cool, filling the pipe nearly to the top with distilled water at laboratory temperature, and covering with a glass plate on a seal of vasoline. The water shall be changed and tested after 24 hours contact on each of three successive days, and on each test shall be free from objectionable color, taste and odor, and from hardness and alkalinity in excess of the limits specified in Sect. 4–16. Determination of hardness and alkalinity shall be made by methods prescribed in Standard Methods of Water Analysis of the American Public Health Association and the American Water Works Association, most recent edition. The purchaser shall indicate in his request for bids the number of tests and test specimens required. At the purchaser's option, this test may be made by him with the water with which the pipe is to be used.

Notes

(These notes are not parts of the standard, but are given for information only.)

(1) The art of making cement-mortar linings for cast iron pipe and fittings which will show maximum smoothness and durability as well as minimum separation, cracking and water solubility is still under active development; for this reason it is the purpose of this specification to leave the manufacturers all possible latitude consistent with insuring a product which shall be of high quality for the present state of the art. Hence, the lack of more definiteness with respect to sand grading and some other features of this specification.

(2) The provision for the use of cements other than standard portland and for other modifications of the mortar, subject to the approval of the purchaser, permits taking advantage of any useful results of the current activity in the development of hydraulic cements of special properties.

(3) The water absorption of cement-mortar linings which have been exposed to the atmosphere diminishes with increasing age of the lining, hence the 30 day limit so that the sample tested shall be reasonably representative of the shipment.

(4) Whitewash is used solely to protect the pipe from the heat of the sun which tends to expand the pipe away from the lining. If other protection is desired, the coal-tar outside coating, to be followed with whitewash in accordance with Section 4–15, may be specified. If cement-mortar-lined pipes

are to be stored for a long time along the trench or in the purchaser's yard, it is recommended that the whitewash be maintained on all sides exposed to the sun. The need for whitewashing varies with the size of the pipe, the climate and probably other conditions. Pipes 16 inches in diameter and larger are more likely to need whitewashing than smaller pipes.

(5) The purchaser who is buying cement-mortar-lined pipe for use with a water that is corrosive to calcium carbonate, such as a soft water of low alkalinity and low pH, is advised either to specify a seal coat or to satisfy himself by appropriate test that the lining to be furnished will not impart objectionable hardness or alkalinity to the water, *considering the amount of circulation in the proposed pipe line and the amount of blowing off of dead ends that he is prepared to do.* The procedure of Section 4–17, omitting the seal coat and substituting for distilled water the water with which the pipe is to be used, is suggested as a convenient form of test.

Another advantage of the seal coat is in prolonging the life of the lining.

(6) The following test for tendency of a paint to impart color, taste, and odor to the water has been used: A 2″ x 3″ x 6″ block of the mortar to be used in lining the pipe is dried, painted and exposed to the air for 48 hours; it is then placed in a covered vessel with a volume of the water of the purchaser's supply equal in cubic inches, to twice the area of the block in square inches (the volume-area relation of an 8-inch pipe). After 48 hours at laboratory temperature it is tested for color, taste and odor. At the date of this specification the following paints, as made at the dates submitted, have passed this test:

No. 119 Shop Coat Black, Harry B. Davies Co., Camden, N. J.

No. 274 Asphalt Paint, H. H. Robertson Co., Pittsburgh, Pa.

No. T-799 Black Air Drying Pipe Paint, Magic City Paint & Varnish Co., Birmingham, Ala.

Gregg's Pipe Coating Enamel, the Gregg Co., 1418 Walnut St., Philadelphia, Pa.

Hunt Process, Johnson-March Corp., 52 Vanderbilt Avenue, New York, N. Y.

Sherwin-Williams Water Tank Coating No. 96, the Sherwin-Williams Co., Cleveland, Ohio.

By changing the water and testing for hardness, total and caustic alkalinity for, say, 3 successive days, and thereafter at longer intervals, an indication of the protective value of the paint may be had.

NEWS OF THE FIELD

A Bull in a China Shop is no more a source of consternation and dismay than is the bull on a printed page. Such a mishap appeared on page one of the News of the Field in the June issue when in the last line on the page our genial President was put (by the Editor's temporary blindness) in charge of building the "new softening plant at Milwaukee." The softening plant he is building is located in Minneapolis. The new filter plant at Milwaukee is completed and in operation—a magnificent plant in a fine city. Such apologies as are called for are hereby humbly tendered.

After many years the A. W. W. A. has at last at Atlantic City demonstrated to itself that a general convention does not have to be held only where there is available a single hotel large enough to house meetings, exhibits, social events and most of those in attendance.

For many years the Convention Place Committee has felt itself compelled to refuse invitations from cities where an auditorium was available for meetings as well as exhibits and where the hotel facilities outlined above were not available.

It was with some apprehension that the Committee, a year ago at New Orleans, decided to try the idea of separating housing and evening social events from exhibits and meetings. Well—it worked! A banner registration, an exhibit that no hotel in America could house, meeting and committee rooms galore—all went together to make 1939 the Year One of a new epoch in A. W. W. A. history. But by no means should it be assumed that conventions hereafter will always follow the auditorium pattern: There are hotels in a few cities large enough to house all events—those cities will be given adequate consideration when future convention locations are being discussed.

In the meantime, the Association's Committee can also consider for conventions those cities where auditoriums have been built.

What does the Convention Place Committee consider when it appraises invitations for A. W. W. A. conventions? Here are some of the items.

It considers first the promotional value to the A. W. W. A. which will result by holding the convention in one or another city. In viewing this point it may consider highly important the possibility of increasing membership in an area where the capacity for greater membership is clearly evident. It may on the other hand attempt to consolidate gains in membership already made in an area by bringing a convention close to

(Continued on page 2)

(*Continued from page 1*)

a large group of new members in an active section. The committee considers the number and loyalty of members in or near a convention city to be an important item. In and out membership records are less desirable than steady and consistent loyalty to the A. W. W. A.

There must be adequate facilities for meetings and exhibits. Both are important. The exhibits are just as important to the active members as they are to the manufacturers. Some believe that the ideas of the exhibitors dominate the opinions of the Convention Place Committee. This is unfortunate and erroneous. They do not dominate but they are given their proper weight. It would perhaps interest many to know that the technical sessions viewed collectively at any hour during the convention seldom include more than a third of the total number of persons registered. Naturally the lady guests are rarely in the technical meetings —although there were noticeable exceptions to this on Monday and Tuesday mornings at Atlantic City. But a very fair proportion of the active members who attend a convention are interested in studying the exhibits with care. They wish to obtain first hand information concerning equipment and look forward to the opportunity. Therefore exhibit facilities are important.

At the same time comfortable and adequate meeting rooms must be had. Air-conditioned meeting rooms are definitely desirable.

Available space for social events, things of interest in the city, the water works plant, things of interest to the wives of members—these also are taken into account when the Convention Place Committee considers its recommendations to the Board.

They were all taken into account when the recommendation was made that Kansas City be the location of the 1940 Convention.

And the Board unanimously authorized the Convention Management Committee to consummate definite arrangements with the Kansas City hotels and the convention bureau for the handling of the 1940 Convention.

A. W. W. A. committees engaged in unusual activity during the 1939 Convention. To some old timers it was reminiscent of the 1925 sessions at Louisville when George W. Fuller was using his famous "dog-whip" on the committees then engaged in preparing the *Manual of Water Works Practice*.

W. W. Hurlbut and his committee on Steel Pipe Specifications carried on practically continuous conferences and made definite progress toward making these specifications available in tentative form to A. W. W. A. members.

J. A. Jensen presided over a session which reviewed certain differences of opinion regarding the thickness of hydrant barrels. This item is the

(*Continued on page 4*)

E.F. DUGGER

General Manager, Newport News, Virginia, Waterworks Commission and Former President of A. W. W. A.

Writes



"We have an 18″ cast iron supply line 16 miles in length, approximately 50 years of age, on which the total repairs for the year 1938, covering labor and material, amounted to slightly less than $40 ($2.50 per mile). This cost for 1938 is a comparable figure for repairs since 1926 at which time I took charge of the system."

E F Dugger

Low maintenance is an economy feature of cast iron pipe that is not confined to Newport News. An impartial survey among 195 waterworks superintendents shows that the maintenance cost of cast iron pipe is *far below* that of any other pipe material which has been in use long enough for the recording of conclusive data.

CAST Q IRON

Look for the "Q-Check" Registered trade mark.
Cast iron pipe is made in diameters from 1¼ to 84 inches.

The Cast Iron Pipe Research Association, Thos. F. Wolfe, Research Engineer, 1015 Peoples Gas Building, Chicago, Illinois

CAST IRON PIPE
PUBLIC TAX SAVER NO. 1

(*Continued from page 2*)

only one that prevents adoption of the hydrant specifications which have been in preparation for 10 years. It is a matter of great regret that a common viewpoint was not reached during the Convention and that further delay must ensue before the completion of this important document.

A committee to draw up specifications on sluice gates held its first meeting.

Thomas H. Wiggin held a meeting of his A21 Committee on Cast Iron Pipe Specifications on Friday, June 16. The Committee had in hand the preprints of its report which had been published for their use by the A. W. W. A. It appears that only a short time will elapse before this very important inter-association project will be approved and ready for public use.

S. F. Newkirk, W. V. Weir, W. A. Peirce and William E. Stanley held meetings of their committees on Meter Specifications, Distribution System Records, Service Line Materials and Distribution System Safety. Weir, Peirce and Stanley along with Sherman Chase (Chairman of the Committee on Cross Connections) held several conferences in order to develop an understanding of each project in the mind of the other Chairmen. It is

(*Continued on page 6*)

For Underground Service Lines

ANACONDA COPPER and RED-BRASS



Anaconda Copper Tubes in straight lengths and coils... Anaconda "85" Red-Brass in straight lengths only – both are products of dependable quality. Made by the world's largest and most experienced manufacturer of copper and brass, and stocked by leading supply houses.

3924

THE AMERICAN BRASS CO.

General Offices: Waterbury, Connecticut

STORE IT in THE OPEN

Until you're Ready to Use it

NO roof or tarpaulin is needed to guard Tegul-MINERALEAD against storm or flood • The ingot ISN'T HURT BY WATER • These 10 lb. blocks are EASILY HANDLED and shipped • COMPOSITION CAN'T CHANGE under jolting in transit • Tegul-MINERALEAD makes PERMANENTLY TIGHT, trouble-free joints, amply able to withstand any vibration • JOINTS HEAL ALMOST AT ONCE. Trenches can be back-filled and traffic hazards cleared up • Send for more information. The ATLAS MINERAL PRODUCTS Company of Pa. Mertztown, Pennsylvania.

A Tegul PRODUCT

Tegul-

MINERALEAD

Now get SOFT...IRON-FREE CITY WATER *this new, economical way*



Investigate Permutit Spaulding Precipitator — NOW

Perhaps you have often wished that your city could have soft, iron-free water. Then you will be interested in this latest development by Permutit—a radical advance in cold lime treatment.

It is Permutit's Spaulding Precipitator! It takes less space and uses less chemicals. The water is softer and more stable. Operation is simpler—requires less attention. Within the last few months, more than a score of these plants have been installed for municipalities, treating water supplies between 5000 gallons and 8,000,000 gallons per day.

The whole story is in the booklet pictured above. In its clear, fully illustrated sixteen pages you will find all pertinent facts of interest to you and your engineering staff.

And remember, the Spaulding Precipitator is made by Permutit—water conditioning headquarters! It is a companion product to the famous Permutit Automatic Zeolite Water Softener and Automatic Filter. For information on any of these products, write to The Permutit Company, Dept. G2, 330 West 42nd Street, New York, N. Y.

PERMUTIT THE WATER CONDITIONING HEADQUARTERS **OVER 25 YEARS**

(*Continued from page 4*)

easily evident that this group of activities promises to produce a well rounded code of Water Supply Distribution. There is a definite need for such a pronouncement on behalf of the Association.

Water Purification Division Committees were active—M. M. Braidech held a conference on carbon research at which several reviews of the work in progress were presented.

The Finance and Accounting Division recommended the appointment of a committee to carry on a nation-wide study of lien laws as related to municipal water department collection of bills.

All things considered, this committee activity is one of the finest evidences of the quality of the A. W. W. A. The fact that the Association is able to obtain the voluntary cooperation of so many leaders and have them devote time during the convention to their work should make plain to anyone interested that water works men are definitely moving forward professionally. It should also make plain to some captious individuals that a water works convention is not a junket nor is it a lark. It is a place for serious business and plenty of hard work.

(*Continued on page 8*)

OVER 500 municipalities use American or New York Continental Jewell Water purification equipment.

WATER FILTERS
WATER SOFTENERS

Proportionate Electro-Magnetic Chemical feeders for feeding lime, acid, alum, soda ash. etc.

AMERICAN WATER SOFTENER COMPANY
Lehigh Avenue and 4th St.
Philadelphia, Pa.

Cathodic Protection
for
Steel Water Tanks

ELIMINATE
Rusting
Corrosion
Pitting
Cleaning
Painting
below the water line.

Guaranteed to save its cost at least *once every four years.*

RUSTA-RESTOR TRADE MARK REGISTERED PATS. PEND.

FREMONT, OHIO

Modern engineering makes it . . .

LIGHT but **STRONG**



Lowering three coupled lengths of 6", Class 150 "Century" Asbestos-Cement Pipe into trench.

The two ingredients of which K & M "Century" Pipe is made—asbestos, and cement—are among the strongest, longest-lived materials known. To take utmost advantage of these qualities, Keasbey & Mattison uses a special manufacturing process that produces asbestos-cement pressure pipe of exceptionally high strength. Each length passes a hydrostatic test of twice its normal working pressure before shipment.

In "Century" Pipe you get not only an unusually strong, durable and long-lasting pipe—you also get permanent relief from the most serious pipe diseases that keep maintenance costs high. No tuberculation. No corrosion. In addition you get "Century" Flexible Couplings which are easy to install and permanently leak-proof.

Isn't this the kind of pipe you have always wished for—the kind that's needed to keep on serving and saving money for generations to come? It is a product of Keasbey & Mattison Company, pioneers in the development of asbestos-cement products.

FREE. Send for new, illustrated catalogue, "Mains without Maintenance." Address Dept. 1017.



KEASBEY & MATTISON

COMPANY, AMBLER, PENNSYLVANIA

SEE K & M'S FIERY SNOWMAN AND EXHIBIT IN THE HOME BUILDING CENTER AT THE N. Y. WORLD'S FAIR

(*Continued from page 6*)

New Materials and Gadgets

1. A Water Hammer Arrester is now available for installation on domestic and commercial water service lines and branches. These units are designed in accordance with studies of Prof. L. H. Kessler of the University of Wisconsin. They are made in sizes ranging from 6- to 134-cubic-inch compression or "hammer" capacity.

2. A Carbon Dioxide Indicator has been developed which is said to be fool-proof—with no valves, clamps, or levelling bottle to manipulate. It weighs about 4 lb. and measures $8\frac{1}{2}$ x 7 x $3\frac{3}{4}$ inches.

3. An Electric Cord that stretches to a length of 7 feet is designed with thick rubber insulation set in coil form so that, when not in use, the cord draws back to a coil about $8\frac{1}{2}$ inches long.

4. Safety Insoles for workers who have to wear rubber boots on rough damp ground have been made of two layers of thin watchspring steel, held in rubber and covered with cloth. It is said that the inner soles will turn nails and other sharp objects from the foot.

5. Stainless Steel Electrodes covering all chemical analyses have been developed upon the principle of analysis of the weld deposits instead of analysis of the wire.

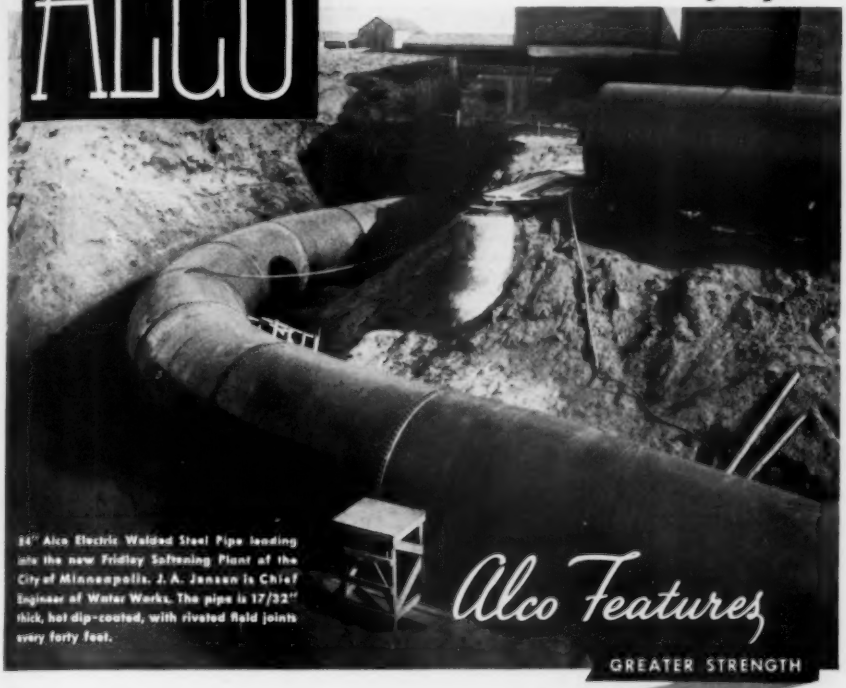
6. Rotable Shelving has been designed to save time and space. It is claimed that each shelving unit will handle three times the usual number of items stored in a given aisle length, therefore two-thirds the usual number of steps may be saved.

7. No Direct Drafts is the claim for a new fan that blows the air toward the ceiling. It is designed to circulate the air in winter as well as in summer, it being claimed that fuel will be saved in winter by circulating the warm air down from the ceiling.

Readers can obtain further information by sending a postal to the A. W. W. A. headquarters giving the reference numbers of any of the above items and citing the July issue as the source.

(*Continued on page 10*)

ALCO ELECTRIC WELDED *Steel pipe*



24" Alco Electric Welded Steel Pipe leading into the new Fridley Softening Plant of the City of Minneapolis. J. A. Jensen is Chief Engineer of Water Works. The pipe is 17/32" thick, hot dip-coated, with riveted field joints every forty feet.

Alco Features

GREATER STRENGTH

LONGER LIFE

SMOOTHER WATERWAY

LONGER LENGTHS

FEWER FIELD JOINTS

LOW INITIAL COST

ULTIMATE ECONOMY

• Since 1897 Minneapolis has been using steel pipe and now has more than 200,000 feet of it over 30" in diameter in water works and sewage service. All this pipe is in excellent condition. The maintenance cost during 41 years of service has been practically nil—no breaks, no shutdowns for repairs.

Why not be guided by the experience of this progressive city?

ALCO PRODUCTS

DIVISION OF

AMERICAN LOCOMOTIVE COMPANY
THIRTY CHURCH STREET NEW YORK, N. Y.

AMERICAN LOCOMOTIVE SALES CORP.
(INCORPORATED IN U.S.A. WITH LIMITED LIABILITY)
ARTILLERY HOUSE, ARTILLERY ROW, LONDON, S. W. 1, ENGLAND

(*Continued from page 8*)

Record attendance at the Atlantic City Convention is revealed in the official total of paid registrations—1,290. This figure well surpasses the previous high of 1,140 paid registrations at Buffalo in 1937 and the 1,123 who paid registration fees at New Orleans in 1938. At Atlantic City there were 450 who registered as representatives of associate members. Of these, 130 were active members in their own name and 320 were guests. The following table shows the record of the past 17 years.

Attendance at A. W. W. A. Conventions

Year	City	Total Registered	Year	City	Total Registered
1923	Detroit	1300*	1932	Memphis	712
1924	New York	1303*	1933	Chicago	660
1925	Louisville	1250*	1934	New York	891
1926	Buffalo	1268*	1935	Cincinnati	901
1927	Chicago	1609*	1936	Los Angeles	891
1928	San Francisco	566*	1937	Buffalo	1140
1929	Toronto	1104	1938	New Orleans	1123
1930	St. Louis	1021	1939	Atlantic City	1290
1931	Pittsburgh	1076			

* No registration fee charged prior to 1929.

(*Continued on page 13*)

48″ Mono-Cast Centrifugal Pipe



Center of interest at A.W.W.A. meeting at Atlantic City was this B&S Cast Iron Pipe centrifugally cast in sand-lined refractory mold by the Mono-Cast method at Acipco. Length, 16 ft.; weight, 8100 lbs. Physicals 25,000 Tensile; 50,000 Modulus of Rupture. Tar-coated outside, and Enamelined inside. Bead cast on spigot end. Approximately 350,000 feet of Mono-Cast Centrifugal Pipe in 30″ and 36″ diameters are giving outstandingly satisfactory service in water and sewage disposal systems, gas transmission and distribution mains, etc., throughout the United States and in foreign countries. Acipco is now furnishing Mono-Cast Centrifugal Pipe in diameters from 3″ to 48″ inclusive. Write for literature.

AMERICAN CAST IRON PIPE COMPANY

BIRMINGHAM, ALABAMA

New York City Chicago Kansas City Minneapolis Dallas Los Angeles
San Francisco Pittsburgh Cleveland

(*Continued from page 10*)

Visits to the Atlantic City water works were enjoyed by many members and guests at the Atlantic City Convention through the hospitality of L. Van Gilder, Engineer and Superintendent of the Atlantic City Water Department. Mr. Van Gilder had numerous autos and chauffeurs on hand at the Convention Hall to take the visitors to the local plant.

Honors, Prizes, and Awards Made at the Convention

Honorary Memberships in the Association were conferred upon: Frank A. Barbour, Consulting Engineer, Boston; Carleton E. Davis, Manager of the Philadelphia Suburban Water Company, Bryn Mawr, Pa.; Charles Gilman Hyde, Professor of Sanitary Engineering, University of California, Berkeley, California; Beekman C. Little, Secretary Emeritus of the Association, Rochester, N. Y.; and Harry E. Jordan, Secretary of the Association, New York.

The Diven Medal, awarded annually to the person whose service on behalf of the Association has been most outstanding, was presented to Hal F. Smith of the Department of Water Supply of Detroit, Michigan, for his leadership of members of the Association and for stimulating them

(*Continued on page 14*)

EDSON
DIAPHRAGM PUMPS

Hand Operated—size 2″, 2½″, 3″, 4″
Power Operated—size 3″ and 4″
Open Discharge or Force Pump
Skid, Truck or Trailer Mounted

Complete Pump Outfits, Genuine Edson Pumps, Suction Hose, Brass Couplings, Bronze Clamps, Red Seal Diaphragms, Brass Strainer or Foot Valve, Hose Spanners, Adapters, Etc. Standard Hydrant Protector, Brass Hydrant Pump.

THE EDSON CORPORATION
Main Office and Works: 49 D St., South Boston, Mass.
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WHITE
FILTER SAND
98% Pure Silica

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Washed, Screened and Dried. No Freight on Moisture—Prompt shipment in Bags or paper lined Box Cars—Write or wire us for information and prices.

DAWES SILICA MINING COMPANY
Silica Mines
THOMASVILLE, GEORGIA

(*Continued from page 13*)

to the fine cooperative activity which made possible the preparation of the *Manual of Water Works Accounting.*

The John M. Goodell award, for the best paper published in the Journal for the year, went to co-authors David G. Thompson and Albert G. Fiedler of the United States Geological Survey for their paper "Some Problems Relating to Legal Control of Use of Ground Waters"—Jour. A. W. W. A., 30: 1049.

The Nicholas S. Hill cup, awarded annually to the section making the greatest percentage gain in membership, was given to the new West Virginia Section which more than doubled its membership (a gain of 117.4 per cent). In second place was the new Ohio Section and third, Minnesota.

The Henshaw cup, given annually to the section having the greatest percentage of its members present at its annual meeting, was awarded to the North Carolina Section. The Montana Section was second.

A new award, the Section-Convention Attendance Award which is a handsome banner for permanent possession and is awarded on the basis of most man-miles of member-attendance at the Convention, went to the Southeastern Section, of whose total of 124 members, 50 came to Atlantic City.

(*Continued on page 17*)

3 Established Facts

Quality, Dependability & Service
Are Synonymous with
"FARNAN"



87 Years of Manufacturing Water Works Brass is your guarantee that FARNAN products will meet with your specifications.

THE FARNAN BRASS WORKS CO.

Cleveland *Established 1852* **Ohio**

IN ATLANTIC CITY— IT'S MATHIESON CHLORINE



Water Department
CITY HALL
ATLANTIC CITY, N. J.

May 4, 1939

The Mathieson Alkali Works, Inc.,
60 East 42nd St.,
New York, N. Y.

Gentlemen:

We are glad to reply to your inquiry concerning our use of your products.

We have been users of Mathieson Chlorine for about 20 years in which time we have received excellent service from your organization.

One feature we have particularly appreciated is the freedom from trouble with clogging tubes. At no time we experienced this difficulty when using another source of supply.

For the past five years we have found your multiple unit cars a great convenience as well as an economy. These cars eliminate extra handling of cylinders because of the greater capacity of the containers.

We are also users of HTH which is highly satisfactory for use in sterilizing our pumping mains, and in addition easy to use.

Yours very truly,

Engineer and Supt.

LVG:B

Lincoln Van Gilder, Engineer and Superintendent, Water Department, Atlantic City, New Jersey

Left, Maurice Brunstein, Chemist and Assistant Superintendent, and right, Frank J. Trumbore, Chief Plant Engineer, who were responsible for the location and design of the new Chlorine Treatment House and its unique facilities for handling ton containers.

The new Chlorine Treatment House, Atlantic City Water Department, showing ton containers of Mathieson Chlorine.

The Atlantic City Water Department, as stated by Mr. Van Gilder in the above letter, have been users of Mathieson Chlorine for over twenty years. Until about five years ago deliveries were taken in 105-lb. cylinders. Then it was decided to take advantage of the economy and convenience of Mathieson Chlorine in multiple-unit tank cars carrying fifteen one-ton containers. Atlantic City also uses Mathieson Ammonia for chloramine treatment and HTH for sterilizing pumping basins, etc.

Atlantic City is only one of many progressive cities throughout the country that find Mathieson Chlorine the ideal answer to the need for a pure chlorinating product—trouble-free containers and valves, prompt delivery service, and courteous, expert cooperation at all times, whether the job be water purification, sewage treatment or swimming pool sanitation.

Write today for a copy of our interesting and informative 80-page manual—"Hypo-Chlorination of Water."

THE MATHIESON ALKALI WORKS INC. 60 EAST 42ND STREET, NEW YORK, N. Y.
LIQUID CHLORINE . HTH . AMMONIA, ANHYDROUS and AQUA . BLEACHING POWDER . SODA ASH . CAUSTIC SODA
BICARBONATE OF SODA . FH-PLUS FUSED ALKALI . DRY ICE . LIQUID CARBON DIOXIDE

ADVERTISING RATES

Journal of the

AMERICAN WATER WORKS ASSOCIATION

22 EAST 40th STREET NEW YORK, N. Y.

1. GENERAL ADVERTISING

(a)

	1 Month (per issue)	3 Months (per issue)	6 Months (per issue)	12 Months (per issue)
1 page	$80.00	$65.00	$55.00	$50.00
½ page	50.00	40.00	35.00	31.00
¼ page	35.00	25.00	20.00	18.00
⅛ page	18.00	14.00	11.00	9.00

1/12 page—Professional Card (under special classification only)..... $3.00

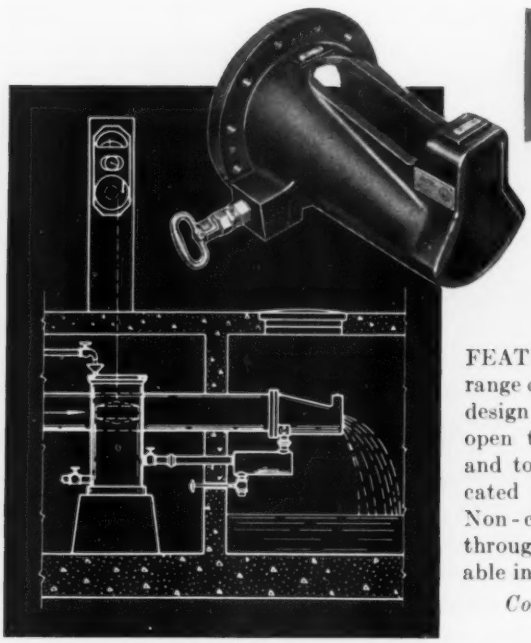
(b, c) No time or space discounts.

(d) Covers and special positions—Yearly basis.
Outside front—no advertising.
Inside back..... $60.00
Other special positions..... 60.00
Inside front..... 65.00
Outside back..... 90.00

(e) Minimum size of advertisement is ⅛ page—2⅛" long x 1¾" deep (except Professional Card—1/12 page under special classification).

(f) Space to be used within one year from date of contract.
Color and insert rates on application.

2. CLASSIFICATIONS—(a, b)—None. (c, d)—Professional Card—1/12 page. Limited to advertisement of professional services. Further information upon request.



Type M Register-Indicator-Recorder Connected to Kennison Open Flow Nozzle.

BUILDERS

Kennison Nozzle

Measures flow in partially filled pipes and open channels.

FEATURES . . . Accurate over wide range of flow • Simple "self-scouring" design • Easy inspection through open top • Recording, indicating, and totalizing instruments can be located nearby or at any distance • Non-clogging design — continuous through-way to pass debris • Available in sizes from 6" to 36" diameter.

Completely described in NEW Bulletin 308

BUILDERS IRON FOUNDRY
9 Codding St. Providence, R. I.

(Continued from page 14)

An Old Oaken Bucket was awarded to the California Section for having the largest roster in the Association on June 11, the opening day of the Convention. Roger Esty, Superintendent, Water Dept., Danvers, Mass., set out to find the bucket many months ago. Massachusetts was considered a fruitful field for such a search, but Esty did not find it so and many a Sunday discovered him wandering into other New England states. He had an agent or two here and there and antique dealers helping him in the hunt. He drove up grass-covered lanes to find the old folks at home, but no old oaken bucket. Sometimes he found an old chain in an



Roger Esty With One of His Buckets

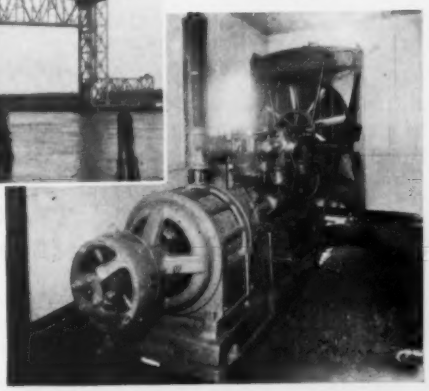
(Continued on page 18)

THE GOLDEN GATE BRIDGE—*San Francisco*
TRIBOROUGH BRIDGE—*New York*
WELLAND CANAL BRIDGES—20—*Canada*

Sterling
High
Duty
Internal
Combustion
Engines



Cape Cod Canal Bridge at Buzzards Bay, Massachusetts, project of U. S. Engineers, is equipped with 125 K.W. 1200 R.P.M. generator, driven by Sterling Dolphin C 8-cylinder gasoline engine



The Pennsylvania Railroad Bridges, C.R.R. of N. J. Bridge, the D.L. & W. R.R. Bridges at Newark, the New York State Bridges at Albany, most all of the prominent bridges in the past 20 years have Sterling Engines, either for primary power or emergency.

The accumulated data, covering all details required for a successful installation—yours on request.

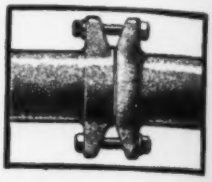
Sterling Engine Company
Dept. C-1

Home Office and Plant
1270 Niagara Street
Buffalo. N. Y.

Branch Office
900 Chrysler Bldg.
New York. N. Y.

UNIVERSAL CAST IRON PIPE

LAID WITH JUST WRENCHES





No other tools are needed. No lead, no pouring, no bell holes to dig. Machined iron-to-iron flexible joints. SPEEDIEST...EASIEST ...SAFEST. Highest quality Cast Iron.

THE CENTRAL FOUNDRY COMPANY

General Offices: 386 FOURTH AVENUE, NEW YORK

CHICAGO, ILL., 1105 W. 36th St. - OAKLAND, CALIF., 278 Fourth St.

OFFICES IN PRINCIPAL CITIES COAST TO COAST

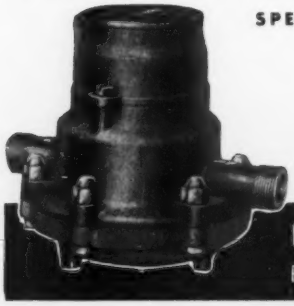
(*Continued from page 17*)

old well, but no old oaken bucket. Sometimes a galvanized pail would have replaced the oaken one, and often motor-driven pumps had deposed the traditional means of getting water out of a well. Finally North Reading, Mass., yielded up a bucket the worse for repair, but really oaken and really old, and Esty fixed it up. Now it's gone out to the old mission country, where the men promise to care for it well until another section's rollcall exceeds that of California.

George W. Fuller awards are given each year to members of the Association deserving of recognition for some outstanding service in the water works field. Awards this year by section were: California—G. E. Arnold; Canadian—A. M. Bowman; Central States—E. C. Trax; Florida—A. P. Black; Four States—J. W. Armstrong; Illinois—J. R. Baylis; Indiana—H. A. Dill; Michigan—H. F. Smith; Missouri—J. W. Pray; Montana—F. E. Brandis; New Jersey—W. G. Banks; New York—E. P. Stewart; Ohio—W. R. LaDue; Ohio—W. C. Lawrence; Pacific Northwest—Alex Lindsay; Rocky Mountain—D. E. Kepner; Southeastern—A. A. Passolt; Southwest—F. W. E. Weisse; Wisconsin—L. A. Smith.

(*Continued on page 20*)

FIRST QUALITY METERS EXCLUSIVELY



SPECIFY *American* or *Niagara*

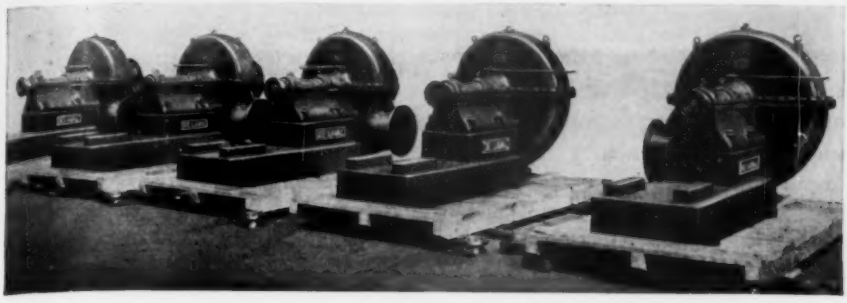
(BRONZE CASE) (IRON CASE)

Water Meters

WRITE FOR CATALOG

BUFFALO METER COMPANY

Established 1892 2914 Main St., Buffalo, N. Y.



Five of a shipment of seven Clogless pumps, six of which are designed to deliver 10,400 g.p.m. each against 15 ft. at 294 r.p.m., and one to deliver 7000 g.p.m. against 27 ft. at 547 r.p.m.

Superior Features of DE LAVAL CLOGLESS PUMPS

1 The casing is split in the plane of the shaft so that the pump can be disassembled without disturbing piping. The inlet is also accessible through a large handhole.

2 The single-inlet, overhung impeller has wide passages without sharp corners where fibrous materials could accumulate, but, at the same time, provides guidance for the water to obtain high efficiency and to avoid cavitation.

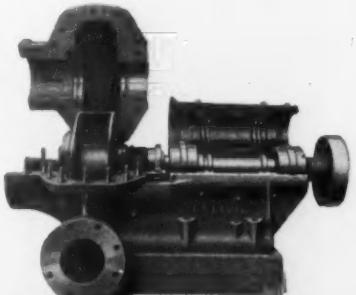
3 Wearing rings protect both impeller and casing at the joint separating the suction from the discharge space, to reduce leakage and to make it possible to restore the original efficiency at little cost. The rings can be sealed with clear water to keep out grit.

4 To reduce overhang, the stuffing box is located over the hub of the impeller, which is protected by a renewable sleeve. A clear water seal can be used to protect the packing.

5 The heavy shaft is carried in ball bearings spaced well apart and supported by a bearing pedestal cast integrally with the pump casing.

Upon receipt of data concerning the character of the liquid to be pumped and the head and capacity requirements, our Engineering Department will submit recommendations and estimates.

Ask for a copy of the paper on SEWAGE PUMPS read before the American Society of Mechanical Engineers by A. Peterson, Chief Engineer of the De Laval Pump Department.



Clogless pump with enclosed impeller; casing cover and bearing cover lifted to show accessibility of impeller and wearing rings, also large size ball bearings, spaced well apart to prevent vibration.

DE LAVAL Steam Turbine Co.
TRENTON, N. J.
MANUFACTURERS OF STEAM TURBINES, PUMPS - CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, CENTRIFUGAL BLOWERS AND COMPRESSORS, WORM GEARS, HELICAL GEARS, HYDRAULIC TURBINES AND FLEXIBLE COUPLINGS — SOLE LICENSEE OF THE BAUER-WACH EXHAUST TURBINE SYSTEM

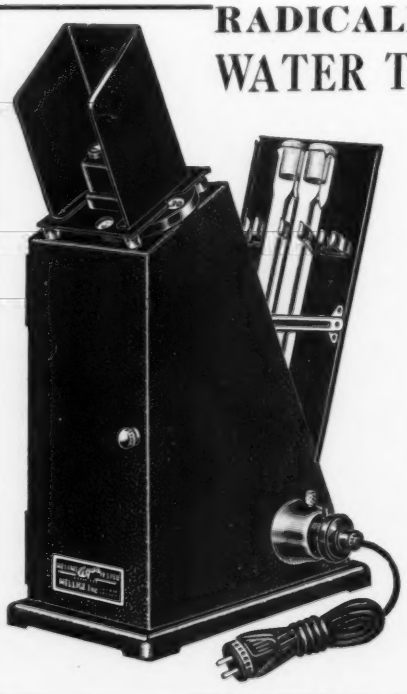
(*Continued from page 18*)

Exhibits at the Atlantic City Convention set an all time record for size and attractiveness. Under the chairmanship of J. Herman Smith, about 20,000 square feet of floor space was laid out in attractive booths and aisles, with nearly 90 associate members exhibiting. There were about 110 associate members registered at the Convention.

Mr. Smith had arranged an attractive fountain in the middle of the exhibit space and adjoining the exhibits a Lounge Reservoir was arranged with restful chairs grouped inside a living hedge.

New Directors taking office on June 15 at the Atlantic City Convention were:—from the California Section, H. A. Van Norman, Los Angeles, succeeding Nelson A. Eckart, San Francisco; from the Florida Section, John R. Tanner, West Palm Beach, Florida, succeeding A. P. Black, Gainesville, Florida; from the Four States Section, Abel Wolman, Baltimore, succeeding Charles H. Becker, Philadelphia; from the Illinois Section, Frank C. Amsbary, Jr., Champaign, Illinois, succeeding Harold E. Babbitt, Urbana, Illinois; from the Minnesota Section, Felix Seligman, Duluth, succeeding Leonard N. Thompson, St. Paul; from the Montana

(*Continued on page 22*)



RADICALLY IMPROVED
WATER TEST COMPARATOR

The new Hellige Aqua Tester combines the thoroughly demonstrated advantages of Hellige *non-fading glass color standards* with radical improvements in design. This new model is, we believe, the most advanced type ever brought on the market and demands special consideration as it brings to its user the utmost in permanent reliability, accuracy, convenience and, last but not least, economy. Standards for all popular A. P. H. A. and A. W. W. A. Methods and Hydrogen Ion Control are available.

Write for Bulletin No. A-611.

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CENTRIFUGAL PUMPS	STEAM AND POWER PUMPS
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WATER METERS

A complete line of water meters of every type is manufactured by Worthington-Gamon Meter Company, a subsidiary of Worthington Pump and Machinery Corporation.

● *Descriptive literature on any of these products furnished on request*

WORTHINGTON PUMP AND MACHINERY CORPORATION
WORTHINGTON-GAMON METER COMPANY

General Offices: HARRISON, NEW JERSEY *District Offices and Representatives in Principal Cities*

CDB-7C

(*Continued from page 20*)

Section, Wade Plummer, Butte, succeeding Joseph M. Schmit, Lewiston, Montana; from the Ohio Section, Wendall R. LaDue, Akron, Ohio, succeeding Wallace W. Morehouse, Dayton, who was the first director to represent the newly formed Ohio Section; from the Southwest Section, George J. Rohan, Waco, Texas, succeeding John B. Winder, Dallas; from the West Virginia Section, which is a new Section, Mentor Hetzer, Moundsville, West Virginia; from the Western Pennsylvania Section, E. C. Trax, McKeesport, Pennsylvania, succeeding H. Lloyd Nelson, Philadelphia, who resigned; from the Wisconsin Section, Walter A. Peirce, Racine, Wisconsin, succeeding the late Arthur H. Miller.

The new director representing the Water Works Manufacturers Association is John a Kienle, New York, N. Y., succeeding Denis F. O'Brien, East Orange, N. J.

J. Arthur Jensen, President of the Association, 1939–40 is a new ex-officio member of the Board of Directors. Mr. Jensen succeeds Reeves Newsom who in turn succeeds Eugene F. Dugger as Past President among the ex-officio members of the Board. Norman J. Howard, Toronto,

(*Continued on page 26*)

DIFCO

Presumptive and Confirmatory Media for Detection of Coliform Bacteria

This group of Dehydrated Culture Media, Difco, is prepared expressly for the detection of coliform bacteria in water. Each medium conforms to the requirements of "Standard Methods of Water Analysis" 1936, in ingredients, formula and reaction. Results obtained by the use of these standardized media are reliable and comparable.

Bacto-Lactose Broth
Bacto-Brilliant Green Bile 2%
Bacto-Crystal Violet Lactose Broth
Bacto-Fuchsin Lactose Broth
Bacto-Formate Ricinoleate Broth
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Specify "DIFCO"
THE TRADE NAME OF THE PIONEERS
In the Research and Development of Bacto-Peptone and Dehydrated Culture Media

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Analysis of the water supplies for municipalities, industrial plants, private estates and camps. Swimming pool control.
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Engineers
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Water Distribution Studies
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Help Build up Your Association by Bringing in a New Member
SEND FOR APPLICATION BLANK
AMERICAN WATER WORKS ASSOCIATION
22 East 40th St. NEW YORK CITY

(*Continued from page 22*)

Ontario, in the new office of Vice President is also a new ex-officio member of the Board.

Changes among the Division Officers were as follows: In the Finance and Accounting Division, Dale L. Maffitt succeeded M. F. Hoffman as Chairman and John C. Flanagan became Vice-Chairman, Hoffman succeeding Hal F. Smith as a Director of the Division. In the Plant Management Division, A. P. Kuranz succeeded Thomas L. Amiss as Chairman, and L. S. Vance became Vice-Chairman. A. M. Brenneke became Secretary-Treasurer of the Plant Management Division, succeeding D. D. Gross, and Scotland G. Highland and W. L. McFaul succeeded Samuel F. Newkirk and L. S. Vance as Directors. Charles H. Spaulding succeeded Charles Gilman Hyde as Chairman of the Water Purification Division, and Paul Weir became Vice-Chairman. M. M. Braidech and Mr. Hyde, as Past Chairman, became members of the Executive Committee, succeeding William M. Wallace and Paul Weir.

(The complete list of Directors and Officers appears on page ii in the front of the JOURNAL.)

(*Continued on page 28*)

CLEAN YOUR WATER MAINS

One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

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208 E. Forsyth St., Jacksonville, Fla.
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2587 Glen Echo Drive, Columbus, Ohio
501 Howard St., San Francisco, Calif.
58 Pelham Ave., Toronto, Canada.



HOW TO PICK THE RIGHT GATE OR GLOBE VALVE

FOR A SPECIFIC SERVICE

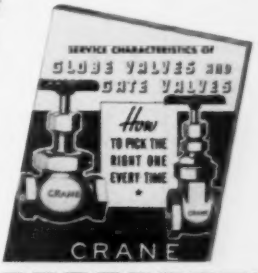
THERE is no such thing as any one valve to meet *every* service. The very feature, for instance, that makes a ball type disc valve ideal for hot oil lines, makes it unsuitable for throttling. And when a valve leaks, it doesn't necessarily mean that only the seat is at fault—that valve may be the wrong type for the service on which it is used.

In almost any service there is one valve that will perform better than any other. That is why the Crane Catalog lists thousands of valves—to assure your getting the one that exactly fits your requirements.

The problem, then, is how to pick the right one. As a matter of fact you, who know the actual conditions of your service, are in a better position than anyone else to select the valve you should use.

Get This Valuable Guide Free

To assist you in making this selection we have prepared a bulletin, "Service Characteristics of Globe Valves and Gate Valves," containing a useful chart designed to help you work out your requirements. It greatly simplifies your selection by showing the service characteristics of each type of valve. A copy of this valuable bulletin will be sent to anyone interested—mail the coupon below.



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836 So. Michigan Ave., Chicago, Ill.
Gentlemen: I want a copy of your bulletin, "Service Characteristics of Globe Valves and Gate Valves."
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Address.....
City.....*State*.....

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

(*Continued from page 26*)

Automobiles were the chief means of transportation to the Atlantic City Convention according to the records of Transportation Committee Chairman John S. Warde. Only 33 went from New York to Atlantic City on Sunday, June 11, while 59 went from Atlantic City to New York (World's Fair) on June 16. Two railroad cars reserved by the Committee for transportation from Chicago to Atlantic City carried only 36 people. From these exact counts and from estimates, a total of no more than 200 of the 1290 registered at the Convention can be attributed to train travel. These figures demonstrate that only a very few main routes should be considered by the Transportation Committee for special trains.

Manufacture and delivery of 15 miles of 84- to 150-inch reinforced concrete pipe for the Metropolitan District Water Supply Commission of Boston are described in detail in a 4-page booklet issued by the Lock Joint Pipe Company, Ampere, N. J.

S. Morgan Smith Company has published a 96-page book giving such complete information about cone valves that its publishers have called it a

(*Continued on page 30*)

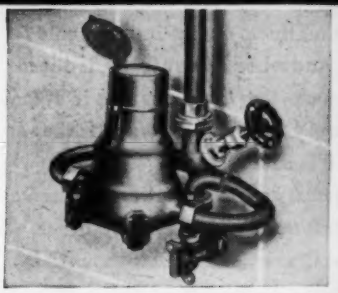


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FIRE HYDRANTS

have been constantly improved for fifty years.
Specification sheets sent on request.

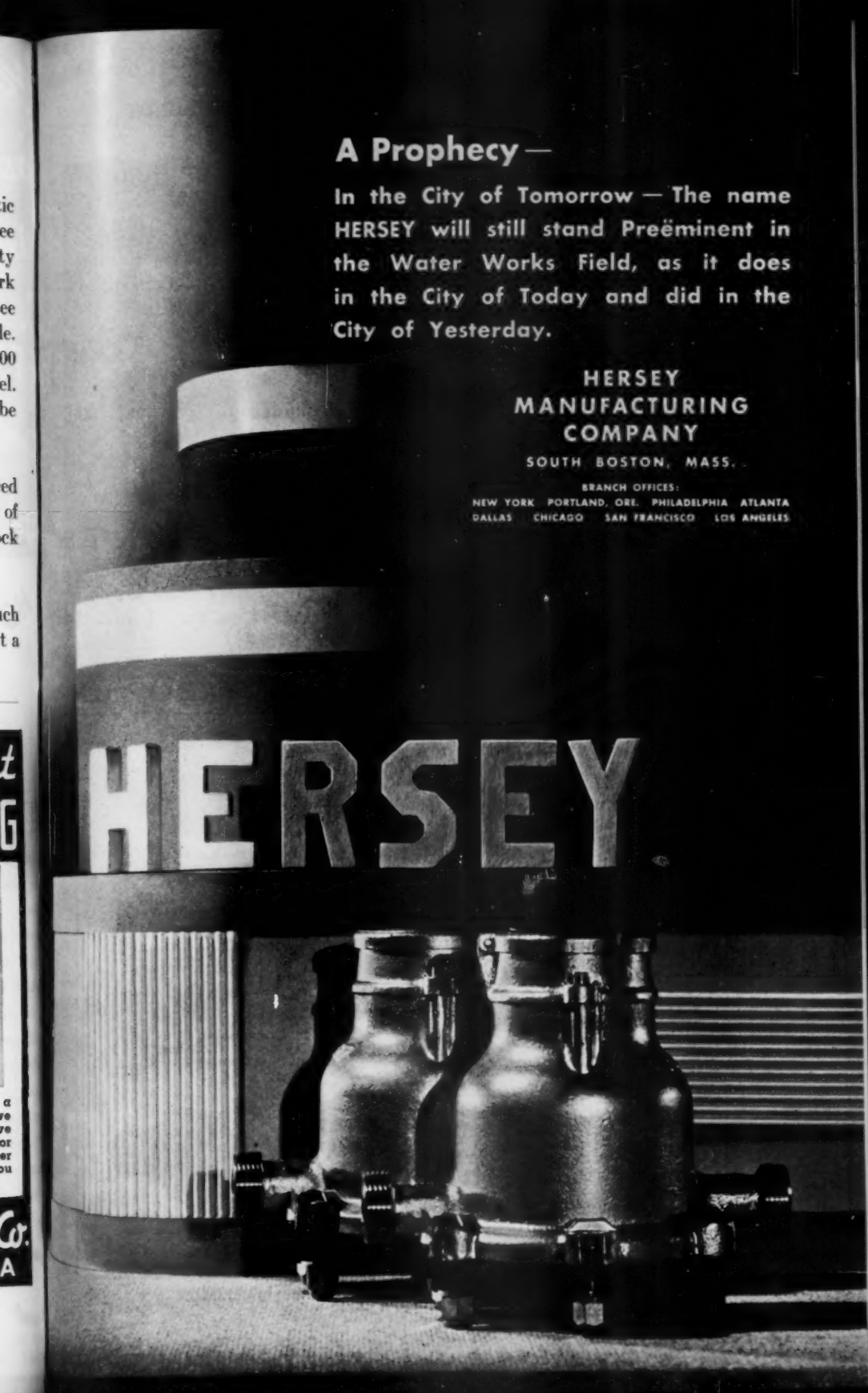
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Correct Basement
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Shown here is a meter setting with a Ford Angle Valve and a Ford Valve COPPERHORN. The compression valve in the COPPERHORN is convenient for shutting off back water or for customer use in repairing faucets. Let us tell you more about modern meter settings.

The Ford Meter Box Co.
WABASH, INDIANA


A Prophecy —
In the City of Tomorrow — The name HERSEY will still stand Preëminent in the Water Works Field, as it does in the City of Today and did in the City of Yesterday.
HERSEY MANUFACTURING COMPANY
SOUTH BOSTON, MASS.
BRANCH OFFICES:
NEW YORK PORTLAND, ORE. PHILADELPHIA ATLANTA
DALLAS CHICAGO SAN FRANCISCO LOS ANGELES
HERSEY

(*Continued from page 28*)

text book. The title is "Rotovalves by Smith", or Bulletin 140, obtainable direct from the S. Morgan Smith Company, York, Pa.

Cathodic protection of steel water tanks is now described in detail in a booklet issued by the Electro Rust-Proofing Co., 38 N. Jefferson St., Dayton, Ohio. Described are specific applications by the Electro Rust-Proofing Co., of which E. H. Ingle is General Manager and A. W. Ingle is Superintendent of Installations.

American Cast Iron Pipe Company of Birmingham, Alabama, has issued a 32-page brochure describing installations of large-diameter pipe in various cities of the U. S., Territory of Hawaii, and Guatemala. The centrifugal method of casting is also illustrated.

John Edward Jackson was elected President of the Pittsburgh-Des Moines Company on June 5 to succeed his father who died April 26, 1939. Mr. Jackson was graduated in Civil Engineering from Iowa State College, Ames, Iowa, in 1924. Since his graduation he has been actively connected with various departments of the Pittsburgh-Des Moines Company and its

(*Continued on page 32*)

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C-129 Corporation Stop Quarter or 90° Coupling Lead Pipe Connection

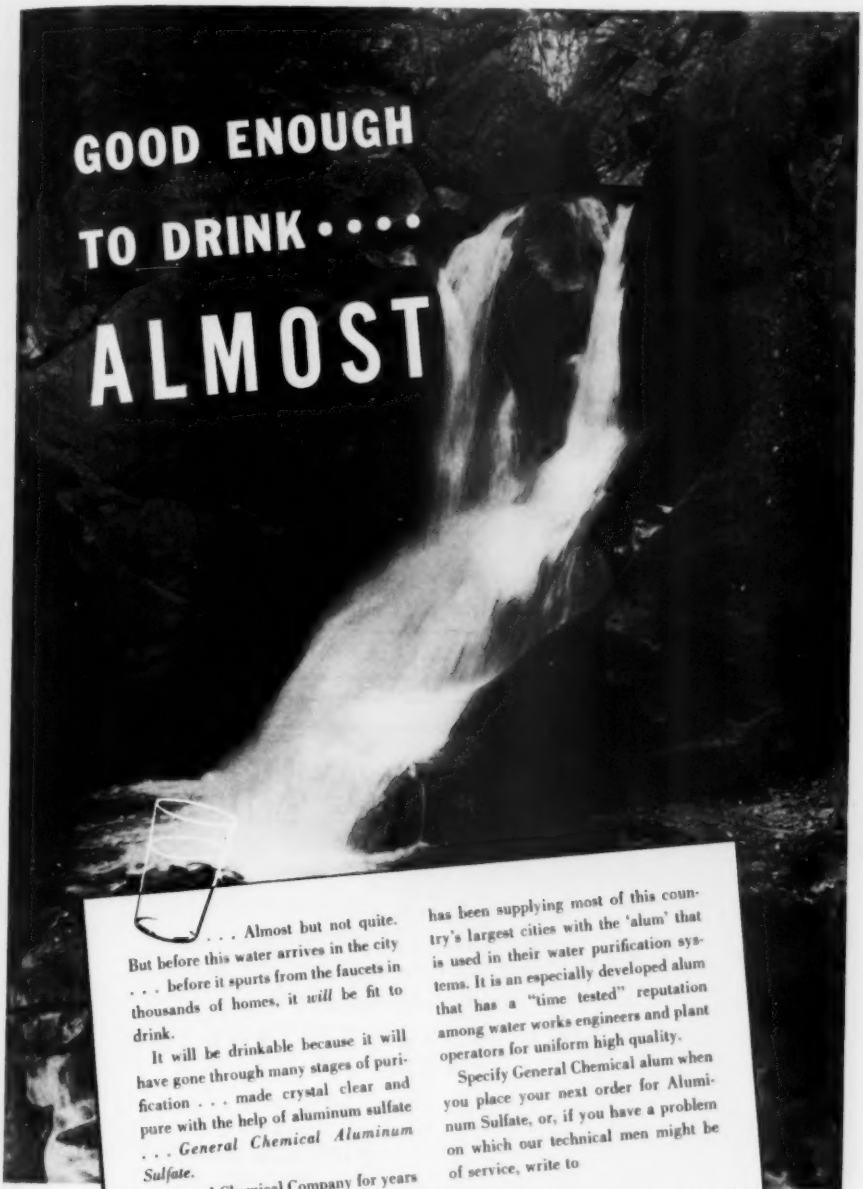


C-127 Corporation Stop Eighth or 45° Coupling Lead Pipe Connection

K-CO
TRADE MARK
of Enduring Quality



C-128 Corporation Stop Less Coupling



. . . Almost but not quite. But before this water arrives in the city . . . before it spurts from the faucets in thousands of homes, it *will* be fit to drink.

It will be drinkable because it will have gone through many stages of purification . . . made crystal clear and pure with the help of aluminum sulfate . . . *General Chemical Aluminum Sulfate.*

General Chemical Company for years has been supplying most of this country's largest cities with the 'alum' that is used in their water purification systems. It is an especially developed alum that has a "time tested" reputation among water works engineers and plant operators for uniform high quality.

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GENERAL CHEMICAL COMPANY **ALUMINUM SULFATE**
A BASIC 'ALUM' CONTAINING NOT LESS THAN 17.0% AVAILABLE Al_2O_3

(Continued from page 30)

affiliate, the Pittsburgh-Des Moines Steel Company. Mr. Jackson was manager of the Incinerator Department for a number of years and since 1935 has been General Manager of the Construction Department. Under his supervision have been constructed many jobs such as the large Wind Tunnel for N.A.C.A. at Langley Field, Va., the high pressure Wind Tunnel for Massachusetts Institute of Technology at Cambridge, Mass., hangars for the United States Army at Albrook Field, Canal Zone, and for the United States Navy at Coco Solo, Canal Zone. In addition he has directed the construction of numerous municipal water works systems and municipal incinerators in various sections of the country.

William R. Jackson was elected a director of the Pittsburgh-Des Moines Company and also Assistant Secretary and Treasurer. Other officers of the Company, A. C. Pearsall, Vice President, J. E. O'Leary, Vice President, H. W. Ford, Vice President, and Geo. A. Smith, Secretary and Treasurer, remain unchanged.

Frederick T. Mavis has been appointed Professor and Head of the Department of Civil Engineering at Pennsylvania State College, State

(Continued on page 34)

Warren Foundry & Pipe Corp.

ALSO

Warren Pipe Co. of Mass., Inc.

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CAST IRON PIPE

Sizes 2" to 84"

Flanged Pipe *Flexible Joint Pipe*

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Special Castings *Short Body B. & S. Specials*

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WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

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A DEPENDABLE SELF - CAULKING JOINT COMPOUND

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1924—January, May, July, September
1926—January, May, June, September, November
1929—January
1936—April
1937—January, February, March
1938—January

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22 East 40th St., New York

Remember this . . .

maximum accuracy on large and small flows + fewer stoppages and stickages + minimun maintenance =

THE *Empire Meter* FOR MAXIMUM WATER REVENUE

National Meter Company
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San Francisco

(Continued from page 32)

College, Pennsylvania. He was formerly Professor and Head of the Department of Mechanics and Hydraulics at the University of Iowa, Iowa City, and Consulting Engineer of the Iowa Institute of Hydraulic Research.

Elton D. Walker, predecessor of Mr. Mavis, has retired as Professor Emeritus after 39 years as a distinguished leader in civil engineering at Pennsylvania State College. Prof. Walker has been a member of the A. W. W. A. since 1906.

(Continued on page 37)

(Continued from page viii)

Associate Members.

ELECTROMARINE CORP., Mr. Payne Dean, Pres., Westport, Conn.
ELECTRO RUST-PROOFING Co., Mr. E. H. Ingle, 38 N. Jefferson St., Dayton, O.
% PROPORTIONEERS, INC. %, Mr. Jeff Corydon, Pres., 9 Codding St., Providence, R. I.
RED HED MFG. Co., Mr. J. G. Lufkin, Pres., 368 Congress St , Boston, Mass.

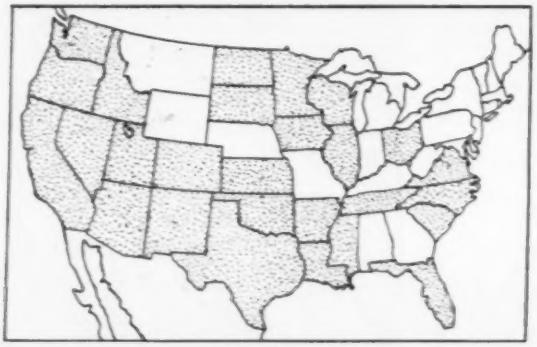
Junior Members.

CRANE, D. EUGENE. Student, 541 Santa Fe Drive, Denver, Colo.

(Continued on page 36)

Is there Fluorine in Your Water Supply?

● **Many water supplies in those areas shaded on the map below contain dangerous quantities of fluorine. Analyses have shown this element to be present in amounts that will mottle or even completely destroy tooth enamel. Such a disfiguration severely handicaps an individual for life.**



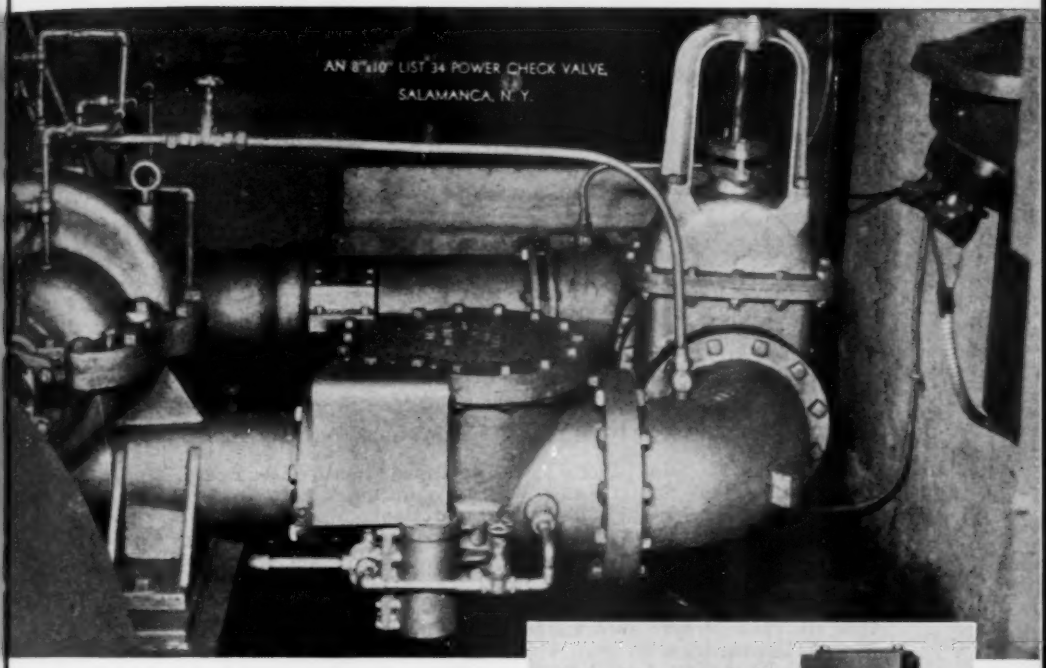
● **How Fluorex Purifiers effectively and economically remove fluorine from water and prevent mottling of tooth enamel is told in Bulletin 2500-A. Write for your copy.**

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FOR QUIET CLOSURE & MAXIMUM EFFICIENCY—INSTALL

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LIST 34 POWER CHECK VALVES





- **Positively eliminates slam on pump shut-down.**
- **Full clearway opening reduces head loss and cuts power costs.**
- **Simplicity of design and rugged construction results in trouble-free operation over a period of years.**

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CC Well Strainers

A reciprocal relation, the life and functioning of the one depending much on the other.

A. D. COOK, INC.
Lawrenceburg - Indiana

COOK Deep-Well Turbine Pumps

(*Continued from page 34*)

Affiliates.

GRECO, A. J. Supt., Riverton & Palmyra Water Co., 1 Morgan Ave., Palmyra, Pa.
SOWDEN, HOWARD J. Jr. Chemist, Minneapolis Water Dept., Fridley Filtration Plant, Minneapolis, Minn.

Reinstatements (Active)

FLINN, THOMAS C. Cons. Engr., 277 Broadway, New York, N. Y.
JOHNSTON, W. E. Sales Representative, National Meter Co., Box 1232, St. Augustine, Fla.
KURTZ, WILLIAM C. Chemist, Western N. Y. Water Co., Woodlawn Station, Lackawanna, N. Y.

Reinstatements (Corporate)

BOARD OF WATER COMMISSIONERS, Water Dept., Mr. R. M. Roper, Secy., East Orange, N. J.
GRAND RAPIDS WATER DEPT., Mr. J. J. Wernette, Supt., Grand Rapids, Mich.

Resignations

BLACKMAN, A. T. Supt., Water Dept., City Hall, Sterling, Colo.
CLARKE, AUBREY B. Topographic Draftsman, Bureau of Water Works and Supply, Box 240 Arcade Annex, Los Angeles, Calif.
HUBBARD, JAMES W. Supt., Smethport Water Co., Smethport, Pa.
NEWCOMB, J. P. Sect., City Water Board, P. O. Box 2449, San Antonio, Texas.

Deaths

JONES, HIRAM F. Supt., Pumping & Filtration, Elmira Water Board, Elmira, N. Y.
MCCLURE, IRA E. Supt., Water Works, Columbus, Mont.
MARVIN, GEORGE. Supt. of Water & Light Dept., Marshfield, Wis.
SWITZER, JOHN A. Cons. Engr., Prof. of Hydraulic & Sanitary Eng., University of Tennessee, Knoxville, Tenn.

Transfers Between Sections

O. C. HOPKINS, from California to Four States.
MAX K. JONES, from Missouri Valley to W. Virginia.
JAMES E. KERSLAKE, from New York to Wisconsin.
C. E. SCHANZE, from New Jersey to Missouri Valley.
BEAUMONT THOMAS, from Ohio to New York.

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Perfection in highly refined, durable, efficient greensand zeolites for open gravity or closed pressure water softeners.

Extensively used with entire satisfaction for over 15 years

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also manufacturers of the well known INVERSAND water softener

(*Continued from page 34*)

Liens against property for payment of water bills are now sanctioned by law in Michigan. The practice of collecting water bills by liens was in force in Michigan, especially in Detroit, for years until a judge ruled that it lacked statutory basis. Facing disruption of established and economical collecting systems, the water works men in Michigan, coordinated under the organization of the Michigan Section of the A. W. W. A., evolved and sponsored a bill in the State Legislature. Laurence G. Lenhardt, General Manager of the Detroit Department of Water Supply, was the spokesman and a leader in the struggle which culminated successfully in Act No. 116 as quoted below. Details of the background of the lien law were given in the News of the Field in April, p. 14, and in June, p. 20.

The matter is of such importance to operators of municipal water works plants in every state that the bill as passed by the legislature and signed by the Governor, is recorded here in full:

SENATE ENROLLED ACT NO. 116

AN ACT to provide for the collection of water rates, assessments, charges or rentals for water, and to provide a lien for water furnished by municipalities as herein defined.

The People of the State of Michigan enact:

Section 1. (a) The word "municipality" as used in this act is hereby defined to be any county, city, township, village or metropolitan district.

(b) The word "person" as used in this act is hereby defined to be any person, firm, partnership, or copartnership or corporation which is the owner or occupant of any house or other building or any premises, lot or lots, or parcel or parcels of land.

Sec. 2. Any municipality which has heretofore or may hereafter operate a water distribution system, for the purpose of supplying water to the inhabitants thereof, shall have as security for the collection of any water rates, or any assessments, charges or rentals due or to become due for the use or consumption of water supplied to any house or other building or any premises, lot or lots, or parcel or parcels of land, a lien upon such house or other building and upon the premises or lot, or lots, or parcel or parcels upon which such house or other building shall be situated or to which such water was supplied. Such lien shall become effective immediately upon the distribution of the water to the premises or property supplied as aforesaid but shall not be encorceable for more than 3 years thereafter.

Sec. 3. The lien created herein may be enforced by any such mu-

(*Continued on page 38*)

(*Continued from page 37*)

nicipality in the manner prescribed in the charter of any such municipality, by the general laws of the state providing for the enforcement of tax liens or by ordinance duly passed by the governing body of the municipality. The provisions of this act shall apply only to municipalities in which a lien on real property for water assessments is now or shall hereafter be provided for by ordinance in accordance with the charter provisions of such municipality.

Sec. 4. The official records of the proper officer, board, commission or department of any such municipality having charge of the water distribution system shall constitute notice of the pendency of said lien.

Sec. 5. The lien hereinbefore created shall from and after the passage of this act have priority over all other liens except taxes or special assessments whether or not such other liens accrued or were recorded prior to the accrual of the water lien herein created: *Provided, however,* That the provisions of this act shall not apply in any instance where a lease has been legally executed, containing a provision that the lessor shall not be liable for payment of water bills as to any such bills accruing subsequent to the filing of the affidavit hereinafter provided for: *Provided further,* That an affidavit with respect to the execution of such a lease containing the expiration thereof shall be filed with the board, commission or other official in charge of the water works system, and 20 days' notice shall be given by the lessor of any cancellation, change in or termination of the lease.

Sec. 6. Any municipality may discontinue water service from the premises against which the above lien has accrued whenever any person shall fail to pay the rates, assessments, charges or rentals herein referred to, or may institute suit for the collection of the same in any court of competent jurisdiction, but no attempt to collect such water rates, assessments, charges or rentals by any process, shall in any way invalidate or waive the lien, upon the premises.

Sec. 7. This act shall not repeal any existing statutory charter or ordinance provisions providing for the assessment or collection of water rates, assessments, charges or rentals by any municipality, but shall be construed as an additional grant of power to any now prescribed by other statutory charter or ordinance provisions, or as a validating act to validate existing statutory or charter provisions creating liens herein provided for.

Sec. 8. Should any provision or section of this act be held to be invalid for any reason, such holding shall not be construed as affecting the validity of any remaining portion of such section or provision of this act, it being the legislative intent that the balance of this act shall stand notwithstanding the invalidity of any such provision or section.

This act is ordered to take immediate effect.

(*Continued on page 39*)

MABBS

PREVENT WEAR AND CUTTING of rods, plungers and shafts by using

MABBS RAWHIDE PACKING

on your Water Works and Sewage pumps and valves. Practically antifrictional, it saves enough in POWER to pay for itself in a short time. For over 45 years Mabbs Rawhide Packing has proven its superiority over other packings for these purposes.

Why not use it in your plant and benefit thereby?

MABBS HYDRAULIC PACKING COMPANY, *Inc. 1892*, 431 S. Dearborn St., Chicago, Ill.

(*Continued from page 38*)

William P. Hughes, City Engineer of Lewiston, Idaho, and Past Director of the A. W. W. A., 1936–38, has been named Chairman of the Idaho Engineering Board which was created in 1939 by the state legislature. The Board's duties will be to direct the engineering profession in Idaho, to conduct examinations for licenses, and to rule on charges of misconduct presented.

The Specifications for Gate Valves stand as printed in the JOURNAL for March, 1939. There had appeared to be an error in the phraseology of Section 16.4 and notice was carried on page 34 of this section of the May issue. Re-examination of the documents indicated that this section was intended to refer to 16-inch valves only and not to refer to any other size. Should any reader of this Journal have modified his copy of the text, he should now note that the original text was correct.

William R. Conard, member of this Association since 1904, last May passed the fifty-year mark in private practice as a consulting engineer. Much of his work has been testing of cast-iron pipe, and some years ago when the use of French cast-iron pipe was being considered in this country, Mr. Conard went to France where he was employed to superintend inspection of all shipments of such pipe to U. S. He is active in the affairs of the General Pipe Cleaning Co. of which he is Vice President.

Mr. Conard has been a trustee of the Four States Section and more recently was a trustee and chairman of the New Jersey Section. He was for a number of years Chairman of the A. W. W. A. Committee on Valves and Hydrants. His home and place of business are in Burlington, N. J. where he has been active in civic affairs.

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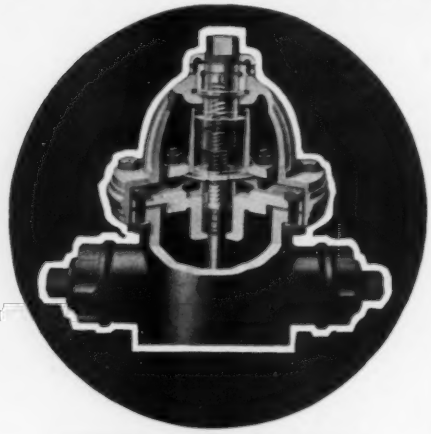
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and
CANADA

1920–1936

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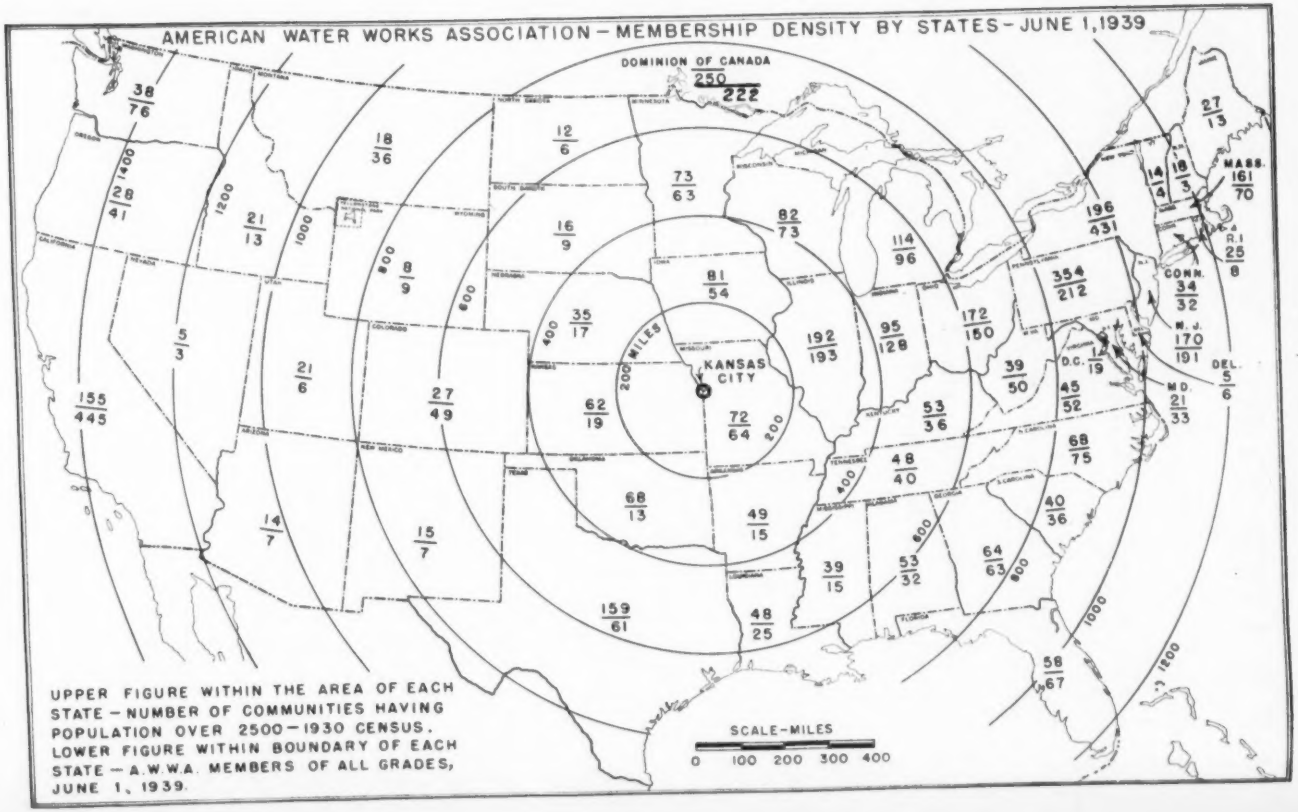
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DOMINION OF CANADA
250
222
38/76
18/36
12/6
73/63
27/13
MASS. 161/70
14/4
18/3
28/41
21/13
16/9
82/73
196/431
R.I. 25/8
8/9
114/96
81/54
354/212
CONN. 34/32
5/3
35/17
192/193
95/128
172/150
N.J. 170/191
KANSAS CITY
21/6
27/49
62/19
72/64
39/50
D.C. 1/19
DEL. 5/6
45/52
MD. 21/33
155/445
53/36
68/75
48/40
68/13
49/15
40/36
14/7
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53/32
64/63
159/61
48/25
58/67
200 MILES
400
600
800
1000
1200
1400
1800
SCALE-MILES
0 100 200 300 400
UPPER FIGURE WITHIN THE AREA OF EACH STATE – NUMBER OF COMMUNITIES HAVING POPULATION OVER 2500 – 1930 CENSUS.
LOWER FIGURE WITHIN BOUNDARY OF EACH STATE – A.W.W.A. MEMBERS OF ALL GRADES, JUNE 1, 1939.

NEWS OF THE FIELD

The 1940 A. W. W. A. Convention is now definitely scheduled for April 21-25 (Sunday through Thursday), at Kansas City, Missouri. The co-headquarters for housing are the Phillips, President and Muehlebach Hotels, rates for which are shown on page 20.

All exhibits and technical sessions will be held in the Auditorium which is located just two blocks away from the hotels. The exhibit facilities are equal—in many ways superior—to those at Atlantic City. J. Herman Smith of the Hersey Manufacturing Company, South Boston, Massachusetts, will again be Exhibit Chairman. The rooms available for meetings are definitely superior to those at Atlantic City.

The Convention Place Committee, in studying possible sites for the 1940 convention, had available a map and tabulation showing the density of A. W. W. A. membership on June 1, 1939 in the various areas where sections have been organized.

A. W. W. A. Membership Density

	COMMUNITIES WITH POPULATION OVER 2500, 1930 CENSUS	A.W.W.A. MEMBERS, ALL GRADES 6/1/39		COMMUNITIES WITH POPULATION OVER 2500, 1930 CENSUS	A.W.W.A. MEMBERS, ALL GRADES 6/1/39
Alabama	53	32	Nebraska	35	17
Arizona	14	7	Nevada	5	3
Arkansas	49	15	New Hampshire	18	3
California	155	445	New Jersey	170	191
Colorado	27	49	New Mexico	15	7
Connecticut	34	32	New York	196	431
Delaware	5	6	North Dakota	12	6
District of Columbia	1	19	North Carolina	68	75
Florida	58	67	Ohio	172	150
Georgia	64	63	Oklahoma	68	13
Idaho	21	13	Oregon	28	41
Illinois	192	193	Pennsylvania	354	212
Indiana	95	128	Rhode Island	25	8
Iowa	81	54	South Carolina	40	36
Kansas	62	19	South Dakota	16	9
Kentucky	53	36	Tennessee	48	40
Louisiana	48	25	Texas	159	61
Maine	27	13	Utah	21	6
Maryland	21	33	Vermont	14	4
Massachusetts	161	70	Virginia	45	52
Michigan	114	96	Washington	38	76
Minnesota	73	63	West Virginia	39	50
Mississippi	39	15	Wisconsin	82	73
Missouri	72	64	Wyoming	8	9
Montana	18	36	Dominion of Canada	250	222

(*Continued on page 2*)

(*Continued from page 1*)

Instead of comparing the number of members with the total number of water works plants, reference was made to communities of more than 2,500 population. The prime reason for this is the fact that the number of water plants in the various states is now growing as a result of federal public works activities. Any figure that might be used today is subject to modification within a few months. The census figure regarding population upon a ten-year basis is a much more permanent reference point.

Another fact is that, while many valuable members of the A. W. W. A. represent communities of less than 2,500 population, in the minds of most persons who have studied membership promotion, the 2,500 line is a good point above which to expect A. W. W. A. members. The tabulation of all states in the U. S. and the Dominion of Canada as a unit is shown on the previous page. This information is also shown on the map opposite page 1.

The figures are striking and deserve the attention of every loyal A. W. W. A. member. It appears that where section activity and organization are at their best, there will be one or more members per town of 2,500 or over. In states such as New York, Illinois and California, the facts are somewhat altered by sizable groups of members in such cities as New York, Chicago, Los Angeles and San Francisco. But by and large the table and the map jointly indicate that where membership loyalty is active and section officers aggressive, there are more A. W. W. A. members than there are cities and towns with 2,500 or more population.

Take California for an example. If we deduct every member in Los Angeles and San Francisco, the remaining total of membership exceeds the 2,500-population towns. There is one sure reason for that situation. The California Section under the leadership of its Membership Chairman, Bill Hurlbut, never lets the week end without something done to build membership in this Association. Other good sections have done comparable work. The Pacific Northwest area is in surprisingly good standing.

Getting back to the Convention Place Committee—when these figures and the map were studied, it became evident that, while the membership ratio in Missouri was fairly good, the general area centering around Kansas City was ready for some real promotional work on behalf of the A. W. W. A. Nebraska, Iowa, Kansas, Oklahoma and Arkansas—all exhibit membership ratios which can be materially improved. The record shows that the A. W. W. A. has never held a general convention between Denver and St. Louis.

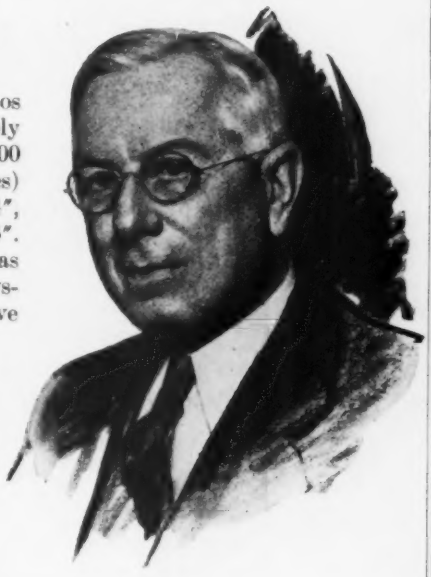
Since the annual convention has been clearly shown to increase membership in the areas near the convention city, the Convention Place Committee said—why not give the upper Missouri Valley a chance to have a

(*Continued on page 4*)

W.W. HURLBUT

(Engineer of Water Works, Los Angeles, Cal. and Former President of A. W. W. A.)

writes:



"In the high value district of Los Angeles, comprising approximately one square mile, there are 147,000 lineal feet (approximately 26 miles) of cast iron pipe in diameters 24″, 20″, 18″, 16″, 12″, 10″, 8″, and 6″. The oldest of this pipe, the 18″, was laid forty-five years ago. The system is operated under seventy-five pounds pressure.

"The maintenance and repair costs for these twenty-six miles of distribution lines for the past ten years amounted to $143.00. Repairs were due to four breaks. This results in the low cost of 55¢ per mile per year."

W. W. Hurlbut

Water mains represent about one-third of this country's 5-billion-dollar investment in public water supply systems. More than 98% of these mains are cast iron pipe with a *known* useful life at least double the *estimated* life of other water main materials. Because the tax-saving, through deferred replacements alone, is enormous, cast iron pipe is known as Public Tax Saver No. 1.

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CAST IRON PIPE
PUBLIC TAX SAVER NO. 1

(*Continued from page 2*)

convention in its own yard and see what membership gains can be made by so doing? Wyoming, Colorado, New Mexico, Texas and Louisiana can come over to a Kansas City convention pretty easily too. The map shows a lot of fine states within 500 miles of Kansas City. Super-service will bring the men from Los Angeles as quickly as those from New York. Kansas City is an amazing center for railroad travel. Our friends from Texas who drive 600 miles a day with the greatest of ease, will ramble up to Kansas City without half trying.

In a nutshell, the need for membership promotion in the great plains area coupled with the fine facilities at Kansas City made the choice of Kansas City a logical and constructive step for the A. W. A. A.

It has been possible, through the cooperation of the executive staff of the A. S. C. E., to coordinate the dates of the A. W. W. A. Convention with the spring meeting of the A. S. C. E. which is also to be held in Kansas City. The latter organization will hold its technical sessions on April 17–19, and this makes it possible for members of the two associations who travel some distance to make but one trip for both meetings.

(*Continued on page 6*)

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deep bell holes or caulking . . . . . .
loss of compound due to rain or flood . . . .
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(*Continued from page 4*)

The International Filter Company has moved its administrative and sales offices from Chicago's loop district to the company's factory at 325 West 25th Place, Chicago. This move was made, according to P. N. Engel, president, to coordinate more effectively the work of the administrative, sales, engineering and production departments.

All manufacturing operations now are confined to the first floor of the main plant building and to a new structure erected during the past year. The engineering, service, development, production and purchasing departments are located on the second floor. The third floor has been completely remodeled to accommodate the executive offices and the sales, advertising, accounting, and laboratory departments.

The United States Public Health Service, after nearly 141 years under the Treasury Department, has been moved to the newly created Federal Security Agency. This move has come about as a result of the President's action under the Reorganization Act of 1939. The U. S. Public Health Service began as the Marine Hospital Service created by an act of Congress signed on July 16, 1798, by John Adams, then President.

(*Continued on page 8*)

Cathodic Protection
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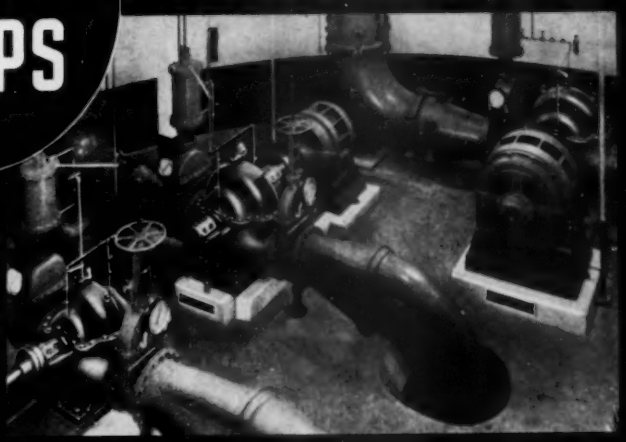
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A $5,000,000 plant, using water in large quantities and operating 24 hours per day the year around, depends for its water supply upon the three De Laval pumps shown in the photograph, continuous operation being provided by connections to a reservoir and to a city water works system.

De Laval pumps are designed with particular regard to reliability in service, viz:

1. The casings are split horizontally in the plane of the axis, so that internal parts are readily accessible and renewable without disturbing piping.
2. Labyrinth wearing rings, which protect casing and impeller and restrict leakage from discharge to suction, give longer life and sustain efficiency over longer periods than do flat wearing surfaces.
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MANUFACTURERS OF STEAM TURBINES; PUMPS – CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT; CENTRIFUGAL BLOWERS AND COMPRESSORS; WORM GEARS; HELICAL GEARS; HYDRAULIC TURBINES AND FLEXIBLE COUPLINGS • • • SOLE LICENSEE OF THE BAUER-WACH EXHAUST TURBINE SYSTEM

(*Continued from page 6*)

Virginia and Massachusetts had previously by state legislation collected money from captains of vessels and established a hospital for seamen in each state. The first hospital operated by the federal govenment was the Virginia hospital at Washington, Norfolk County, which was purchased from that State in 1801. As the country grew, hospitals were established at all important ports on both coasts and at river and Great Lake ports.

Such diseases as cholera, smallpox and yellow fever were often imported into this country by seamen and so doctors in the Marine Hospital Service were often the first in the country to diagnose such diseases. When epidemics broke out in various states, it was quite natural that physicians of the U. S. Marine Hospital Service should be called in to help local authorities. Another factor that led to greater federal participation in health measures was the enforcement of quarantines. Quarantine functions were at first exercised exclusively by states and cities, but as early as 1799 Congress authorized revenue cutters of the Customs Service, in the Treasury Department, to aid in the enforcement of quarantine and health laws. The Marine Hospital Service gradually took over all quarantine functions. Numerous acts of Congress gave it more powers until an act of

(*Continued on page 10*)

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Power Operated—size 3″ and 4″
Open Discharge or Force Pump
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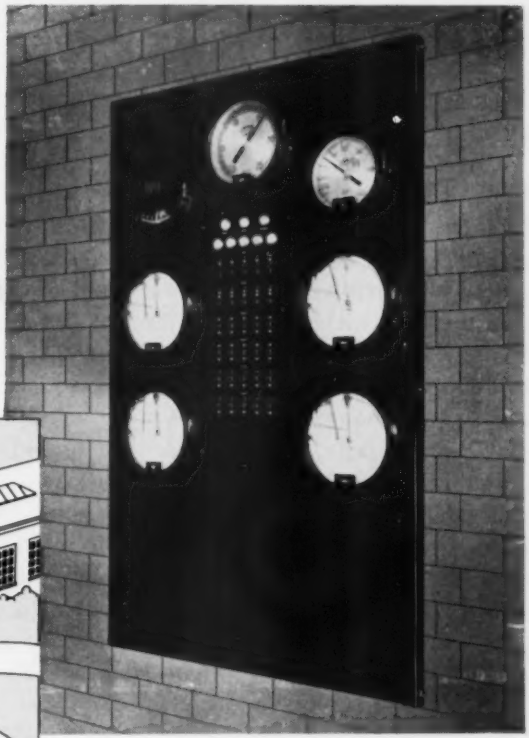
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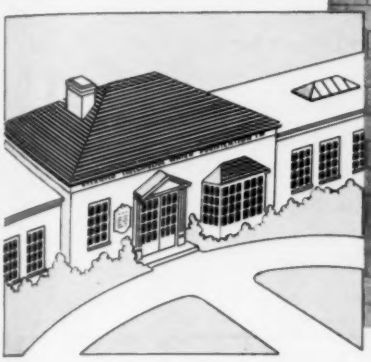
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FOXBORO Instruments

FOR WATERWORKS AND SEWAGE SYSTEMS

(Continued from page 8)

Congress in 1893 gave it quarantine powers over all infectious and contagious diseases, in cooperation with state and local authorities.

In 1902 the Marine Hospital Service became officially the U. S. Public Health and Marine Hospital Service and in 1912 it became the U. S. Public Health Service. In the meantime more and more control over quarantine and health measures was exercised by the federal government, not only in the interstate sense but in direct contact with county agencies. This was not without local opposition, as noted in the federal government's rigorous and successful drive against the plague in San Francisco in 1900 where there was strongly organized local opposition to the methods used to rout the rat from the city.

From activity in preventing the importation and spread of quarantinable diseases, the federal functions were extended to investigation and research. Such diseases as yellow fever and cholera were investigated before Congress in 1901 authorized the building of the Hygienic Laboratory. In 1912 an act extended research functions to the study and investigation of all diseases of mankind including sanitation and sewage

(Continued on page 12)

RUSTOP
the
Cathodic Method of Eliminating and Preventing Rust and Corrosion in Steel Water Tanks.
Eliminates the Necessity of Painting below the Overflow.
Now Used by Many Cities And Manufacturers. Write For List Today.
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(Pat. Pend.)
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3 Money, Time and Labor Saving Features of
UNIVERSAL CAST IRON PIPE
LAID WITH ONLY WRENCHES
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EVERY part of a Kennedy SAFETOP Fire Hydrant is designed to insure minimum pressure loss from water main to nozzle inlet. For example:

Area of standpipes is 200% to 300% of inlet valve areas.

Inlet valve ports have larger diameter than each nominal hydrant size.

Inlet elbows and nozzles are proportioned with easy curves.

There are no sharp corners or pockets where eddies might form.

Interior of standpipe, inlet elbows and nozzles are carefully examined during assembly to make sure that all water passages are perfectly smooth.

Moreover, the Safety Breakable Section which protects the major and expensive parts of the hydrant from damage in case of a smashing collision does not interfere in any way with the normal functioning of the hydrant. Both the standpipe and stem are fully as strong and rigid as any one-piece hydrant, and the simple straight-line operating mechanism works freely and positively at all times.

Fire chiefs are as enthusiastic about the easy operation and dependable service of the SAFETOP Fire Hydrant as are water department superintendents concerning its unique safety and economy features. Kennedy SAFETOPS are a double protection to the community—in fire service and in collision emergencies.

Write for Bulletins

The Kennedy Valve Mfg. Co.
Elmira, N. Y.

KENNEDY

SAFETOP FIRE HYDRANT

REG. U.S. PAT. OFF.

(*Continued from page 10*)

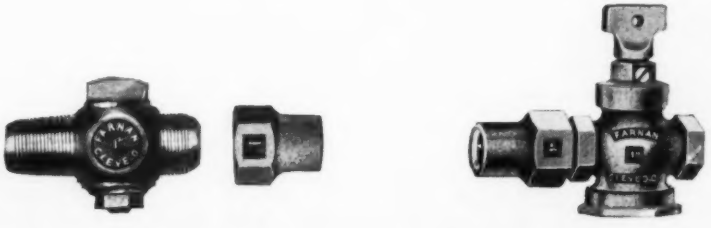
treatment and the pollution either directly or indirectly of the navigable streams and lakes of the U. S. In the last two decades, special divisions have been set up for either the study of, or care for, persons afflicted with venereal diseases, cancer, leprosy, narcotic addiction, mental diseases, and sick and disabled veterans. Under the Social Security Act, $8,000,000 may be granted each year to help state and local agencies set up and maintain adequate health services.

At first the U. S. Marine Hospital Service was naturally and properly under the Treasury Department, but gradually and certainly by the time it was named the U. S. Public Health Service it did not belong there. In spite of being in the charge of officials of fiscal affairs, the Public Health Service has fared moderately well and has done much good work. Under the Federal Security Agency, the way will be open to greater attainments. Included with the U. S. Public Health Service in the Federal Security Agency will be: the Social Security Board, the U. S. Employment Service, the Office of Education, the National Youth Administration, and the Civilian Conservation Corps.

(*Continued on page 15*)

Quality *Plus* and Durability *Plus* Mean
ECONOMY PLUS

TWO WORDS—FARNAN CLEVELAND—are all you need to remember to insure your procuring the highest quality water works brass obtainable at any price anywhere.



THE FARNAN BRASS WORKS CO.
CLEVELAND *ESTABLISHED 1852* OHIO

(*Continued from page 12*)

New Materials and Gadgets

1. A glass pump for handling corrosive liquids is now on the market. It is of the centrifugal type and is designed to deliver, per hour, 6,000 lb. of acid or other liquids 70 ft. above the suction level. Since the pump is transparent, stoppages are easily seen.

2. A variable scale and parallel ruler in one instrument has been designed to embrace all linear units. The operator can obtain any desired divisions or units—degrees, minutes, grades, miles, chains, yards, feet—by rotating a handle until the desired unit passes over the edge member of the scale adjacent to the working surface. The instrument is featured as a standard scale, universal scale, conversion scale and contour interpolator.

3. A ferris wheel type of storage bin for small parts has been developed to save time and space when used by a repairman or shopworker. It has eight troughs with numerous compartments and is 10 inches wide.

4. A small gas cleaner has been developed for use on consumer pipes. Where pipe scale, dust or condensate may be picked up in distribution lines, this new gadget is purported to prevent trouble with pilot light outages, etc.

5. For removing staples from correspondence, a device that looks like a pair of pliers is now on the market. A quick squeeze removes the staple and torn fingernails and torn letters are prevented.

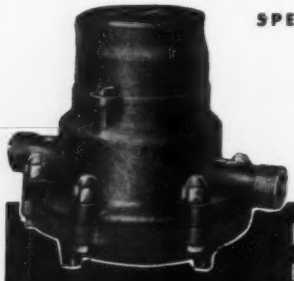
6. A new type of screen cloth has been put on the market which is made of piano wires which are run in one direction only, with no cross wires. The screen cloth is stretched to such a high tension that individual wires develop a resonance so that undersize particles are passed much more rapidly than through the conventional types of cloth.

7. An offset welding tip holder has been developed for use in what are ordinarily inaccessible spots.

Readers can obtain further information by sending a postal to the A. W. W. A. headquarters giving the reference numbers of any of the above items and citing the August issue as the source.

(*Continued on page 16*)

FIRST QUALITY METERS EXCLUSIVELY



SPECIFY *American* or *Niagara*
(BRONZE CASE) (IRON CASE)
Water Meters
WRITE FOR CATALOG

BUFFALO METER COMPANY
Established 1892 2914 Main St., Buffalo, N. Y.

(*Continued from page 15*)

A surplus of $360,000 in the Lake Michigan pipeline construction fund at Grand Rapids, Michigan, has been reported by Arthur W. Consoer, consulting engineer for the lake pipeline project. This is a possible life saver to Grand Rapids because that city currently finds itself short about $200,000 to purchase materials to complete a four-mile feeder main between the water works pumping station and a new reservoir. The reservoir was built as a W. P. A. project, and plans have been made to construct the main in the same manner. It was hoped that the main could be transferred to a P. W. A. project basis and thus save the city from so great an expenditure for materials.

(*Continued on page 19*)

Jesse Shaw, Superintendent of the Tyler, Texas, Water Department, died on July 26. Jesse Shaw was one of the organizers of the Southwest Water Works Association. When that Association became the Southwest Section of the A. W. W. A. in 1935, Shaw was made an Honorary Member of the A. W. W. A., as a tribute to his leadership and long service to the water works field. He had been head of the water department at Tyler for the past 16 years and at Topeka, Kansas, for 31 years previously.

William H. Dittoe, Chief Engineer of the Mahoning Valley Sanitary District, who died on May 27, has been succeeded by Luther T. Fawcett. Mr. Dittoe was formerly Chief Engineer for the Ohio State Board of Health. At the time the Mahoning Valley Sanitary District was formed, Mr. Dittoe became Chief Engineer of that project, a position which he held until his death. Mr. Dittoe was a member of the A. W. W. A. for the past 25 years.

Before succeeding Mr. Dittoe, Fawcett was Mahoning County Sanitary Engineer, having been with the Mahoning County Engineering Department for 20 years.

(Continued from page 16)

1938 was the eleventh consecutive year during which there was no outbreak of water-borne typhoid fever in New York state which could be attributed to the consumption of water from a public water supply system, according to a report made by Dr. Edward S. Godfrey, Jr., State Commissioner of Health. With respect to milk-borne outbreaks, however, Doctor Godfrey said there has been "practically no diminution in the number of such outbreaks and raw milk continues to be the cause."

With regard to the situation as to water-borne typhoid fever, Doctor Godfrey said:

"An epidemic of bacillary dysentery was reported in a village supplied with water from a surface stream and chlorinated before delivery to consumers but the illnesses were attributed to temporary failure of the chlorination equipment for a period of approximately one day. Previously this Department had recommended that a water filtration plant be installed for the effective purification of the supply and the village is planning to provide such a plant. This outbreak shows the need for constant vigilance in the sanitary supervision of public water supplies including close atten-

(Continued on page 20)

Important Telephone Exchanges Employ Sterling Standby Generator Sets

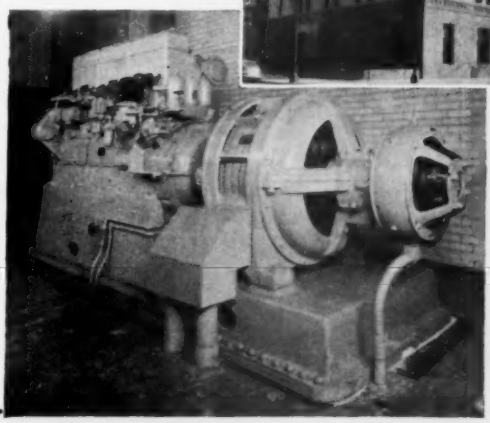
Sterling High Out/ Internal Combustion Engines

The deluge of telephone calls that follow any catastrophe —reporting—appeals for help—the many imperative instantaneous demands must be served.

When utility power fails, these quick starting emergency generator sets furnish auxiliary power instantly.

The special engineering required for a successful installation, is available.





200 K.W. General Electric Generator driven at 1200 R.P.M. by Sterling Viking 8-cylinder 425 H.P. gasoline engine—Underwriters' approved for building installation.

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(*Continued from page 19*)

tion to the adequacy of the control exercised over water treatment equipment.

"Investigation of an outbreak of gastro-enteritis among workmen at the Buffalo airport disclosed that the water supply, derived from a public system, was of satisfactory quality but that secondary pollution had occurred during extensive enlargement and repair of the distribution system on the airport grounds. The new or repaired mains had not been disinfected."

There were 412 typhoid carriers under supervision in upstate New York, exclusive of those in state institutions at the close of 1938, 14 more than were under supervision at the end of the previous year, according to an announcement today by Dr. Edward S. Godfrey, Jr., state commissioner of health. During the year 45 new carriers were added to the register and 31 were removed.

Dr. Godfrey said concerning the 412 typhoid carriers:

"Twenty-seven were discovered as a result of epidemiological investigation of sporadic cases; ten by means of release cultures; three were discovered incidental to attacks of acute cholecystitis; one through an attack of acute cystitis; one through the development of a costal osteomyelitis

(*Continued on page 22*)

American Water Works Association
60th Annual Convention
Kansas City, Mo., April 21-25, 1940

Scheduled Hotel Rates

Rooms	Phillips	President	Muehlebach
Single Bedroom	$2.50- 5.00	$2.50- 5.00	$3.50- 6.00
Double Bedroom, 2 persons	4.00- 8.00	4.00- 6.50	5.00- 8.00
Twin Bedrooms, 2 persons	6.00- 8.00	5.00- 8.00	6.00-10.00
Suites			
Parlor and 1 Bedroom	12.00-15.00	15.00	15.00-25.00
Parlor and 2 Bedrooms		20.00	21.00
Parlor, Dining Room and 2 Bedrooms			35.00
Parlor and 3 Connecting Bedrooms	25.00		
Parlor and 4 Connecting Bedrooms	35.00-40.00		

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(Continued from page 20)

subsequent to typhoid fever; and one through investigation of a positive Widal in a specimen of blood submitted for the agglutination test for undulant fever. Two previously discovered carriers were added to the register, one who was discharged from a state institution and one who came from another state.

"Of the thirty-one carriers whose names were removed from the register, sixteen died. Six were released from restrictions after submission of the required number of specimens. One was released because it was learned that the specimens which resulted in declaration had undoubtedly been contaminated by a chronic typhoid carrier in the same home. Seven carriers moved to other health jurisdictions and one was removed from the active list because of commitment to a state mental hospital.

"Two typhoid outbreaks during the year were traced to carriers. An outbreak of thirteen clinically recognized cases occurring in July was caused by a man subsequently found to be a chronic typhoid carrier who had supplied raw milk to these patients. The second outbreak consisting of three cases was caused by a known typhoid carrier who prepared food consumed by these patients at a picnic.

"Fifteen cases of typhoid fever occurred during the year which were

(Continued on page 27)

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Extensively used with entire satisfaction for over 15 years

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HUNGERFORD & TERRY, Inc., Clayton, New Jersey

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(*Continued from page viii*)

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KACHORSKY, MICHAEL S. Supt., Dept. of Public Works, Box 283, Manville, N. J.
MCBRIDE, SAMUEL P. Chemist, Shenango Valley Water Co., Sharon, Pa.

Affiliates

ALBRECHT, ROBERT H. C. E., Acting Supt., Board of Water, Light & Sewer Comm., Hamilton, N. Y.
FRIESE, JOHN H. Asst. Engr., City of White Plains, 255 Main St., White Plains, N. Y.
GIANNETTI, ARNOLD S. Engr., Montclair Water Bureau, 54 Watchung Ave., Montclair, N. J.
HAMMEL, C. W. Water Plant Operator, Sistersville Water Works, 213 Railroad Ave., Sistersville, W. Va.
RASMUSSEN, CHARLES E. Asst. Mech. Engr., Dept. of Public Works, 895 Gladstone Ave., Detroit, Mich.
RODAN, JOHN T. 61 So. 27th St., Camden, N. J.
SMITH, A. C. Supt. & Operator, Matewan Water Works, P. O. Box 164, Matewan, W. Va.
STAGER, LEO W. Hydrant & Valve Foreman, Montclair Water Bureau, 54 Watchung Ave., Montclair, N. J.
ZELLEY, JOHN W. Watershed Inspector, N. J. State Dept. of Health, Columbus Rd., Burlington, N. J.

Reinstatements (Active)

HOOT, RALPH A. Chief Chemist, Fort Wayne Water Works, Fort Wayne, Ind.
MORROW, GUY. Manager, The Citizens Water Co., 62 E. Wheeling St., Washington, Pa.

Reinstatements (Associates)

W. A. BRIGGS BITUMEN CO., INC. Mr. W. Ronald Briggs, 3303 Richmond St., Philadelphia, Pa.

Resignations

MASTIN, M. G. Chief Chemist, Westvaco Chlorine Prod. Corp., Newark, Calif.

Deaths

LEBOLD, GEORGE. Supt. of Meters, Hackensack Water Co., 624 Park Ave., Hackensack, N. J.

Transfers Between Sections

FREDERICK T. MAVIS, from Missouri Valley to Western Pennsylvania.
J. HUSTON MCCLANE, from Florida to Southeastern.
EMANUEL H. PEARL, from New England to Southwest.
ROY F. WESTON, from New York to Four States.

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6 North Michigan Ave., Chicago, Illinois

(*Continued from page 22*)

believed to have been caused by ten previously known carriers. Eleven of this number were among household contacts of carriers. Nine of these eleven patients had never been immunized, one was immunized in 1934 and the other was immunized before a final diagnosis of typhoid fever was made.

"About three per cent of the typhoid cases reported as having had onset in the previous year, 1937, and who survived the disease, are considered to have become chronic carriers."

The importance of protecting and promoting the health of the individual and the community under rural and urban conditions has led to the establishment at the Massachusetts Institute of Technology of a graduate course in public health engineering, according to an announcement by Dr. Samuel C. Prescott, Dean of Science and head of the Department of Biology and Public Health.

The new course will consider such subjects as water supplies, water purification, sewerage, industrial waste disposal, stream pollution and

(*Continued on page 28*)



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(*Continued from page 27*)

purification, and the sanitation of shellfish grounds. In addition, consideration will be given to the most advanced practice in the collection and disposal of refuse, sanitation of swimming pools, rural communities and camps, as well as the sanitation of food supplies, stores and restaurants. Students will also receive instruction in the relationship of insects and rodents to disease; the atmosphere in relation to health and comfort, housing and health, school sanitation and industrial hygiene. There will also be training in the organization and activities of health departments, the collection, analysis and interpretation of vital statistics, epidemiological methods, the value and conduct of public health surveys, and the use of standard health appraisal forms.

The course, which will begin with the opening of the school year on September 25, will lead to the degree of master of science in one year, and will be open to qualified men of outstanding scholastic attainment and professional promise who are graduates in engineering of a recognized school or college. Candidates must have had at least one year of experience with a city, county or state department of health, the United States Public Health Service, or some other recognized health agency.

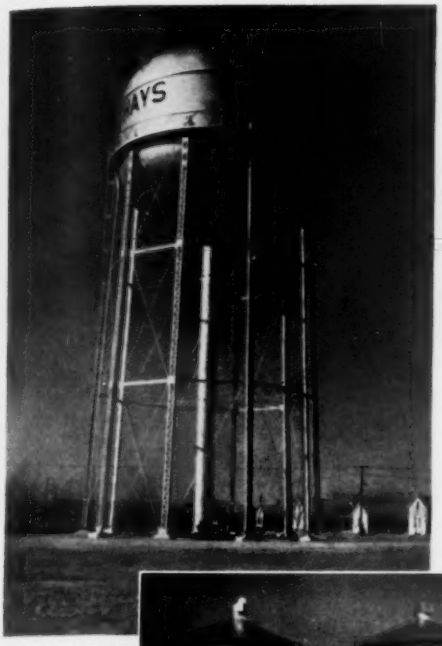
(*Continued on page 30*)

A. W. W. A.
Membership Certificate

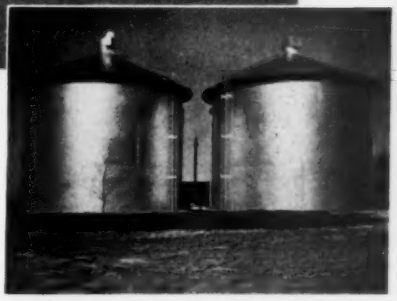
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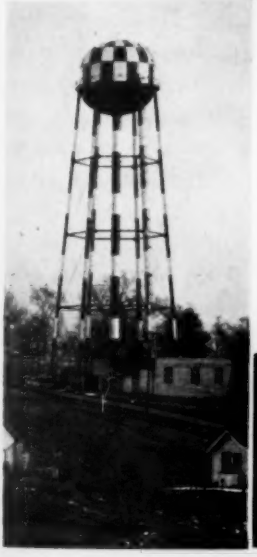
The certificate will reach you within 10 days of receipt of order —ready for you to frame and hang in your office.



P·DM 500,000 gallon Double Ellipsoidal Tank, City of Hays, Kansas. High water line 119' above foundation tops.



P·DM Steel Reservoirs, City of Atlantic, Iowa. Capacity 100,000 gallons each; 30' in diameter, 21' high.



P·DM 150,000 gallon Double Ellipsoidal Tank, North Kansas City, Missouri. High water line 142' above foundation tops.

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or
GROUND STORAGE
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Elevated or ground storage o water, depending upon the nature of the location, is a necessary feature of any modern economically-operated water system. P·DM's engineers can readily determine the type and quantity of water storage your community requires—and assist in the solution of every other question relating to improvement of your service.

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Application Blank on Pages 37, 38
AMERICAN WATER WORKS ASSOCIATION
22 East 40th St. NEW YORK CITY

(*Continued from page 28*)

Professor Murray P. Horwood of the department of biology and public health will direct the courses in public health engineering and vital statistics, while Professor T. R. Camp of the department of civil engineering will give the course in hydraulic and sanitary engineering and sanitary design. The courses in health department practice and industrial hygiene will be given by Professor Clair E. Turner, and the course in sanitary biology by Professor Marshall W. Jennison. Students will be required to present a satisfactory thesis dealing with some original investigation.

A 36-inch main burst recently in Newark, N. J., and according to newspaper reports, sent 3,000,000 gallons of city water flooding into the basements of over 100 homes and business houses. Nearly 1,000 feet of city trolley line was inundated up to a depth of 6 feet. Estimates of the damages ranged up to $200,000. The break occurred at 4:30 P.M. and water flowed for over five hours before it was completely shut off. The break created a hole 45 feet wide in the pavement. Finding the leak was difficult because three 36-inch mains are located at the point where the leak occurred. The graph at a water tower, however, revealed that pressure in a downtown feeder main had dropped from 100 to 60 pounds, and engineers and crew labored nearly four hours to shut down 24 gate valves necessary to stop the leak in the feeder main and still leave service intact to major portions of the city.

A 36-inch main feeder line burst on August 9 in Manhattan, depriving many residents of water and reducing pressure to other consumers. Under a 175-pound pressure, the main burst and quickly un-

(*Continued on page 32*)

Trade Mark MABB'S Reg. U. S. Pat. Off.
PREVENT WEAR AND CUTTING of rods, plungers and shafts by using
MABBS RAWHIDE PACKING
on your Water Works and Sewage pumps and valves. Practically antifrictional, it saves enough in POWER to pay for itself in a short time. For over 45 years Mabbs Rawhide Packing has proven its superiority over other packings for these purposes.
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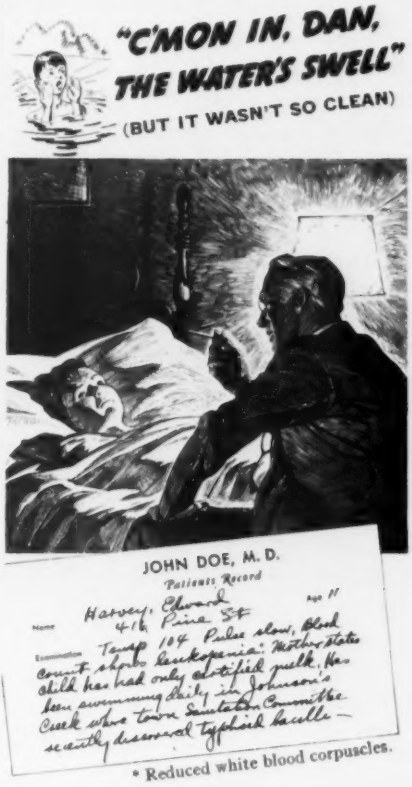
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American Water Works Association
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* Reduced white blood corpuscles.

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SOLVAY
LIQUID CHLORINE

(*Continued from page 30*)

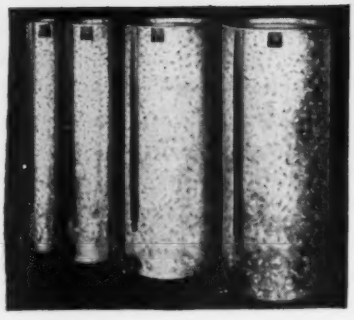
dermined a 20 ft. square section of pavement. The break occurred at 6:15 A.M. and water flooded the streets until about 8:30 A.M. when an emergency crew had valves closed. By 9:30 A. M. another supply had been cut in and residents enjoyed at least a low pressure supply. Area affected was from 59th St. to 131st St. across the entire island. Surface cars were halted by the water in the trolley slots.

The World of Tomorrow will use plenty of water if the New York World's Fair is any indication. Five of the major water displays use 186,500 gallons per minute or 268 million gallons per day. Very little of this is consumption, however, for water for the displays is recirculated. Actual consumption at the New York Fair is between 7 and 9 m.g.d., of which between $3\frac{1}{2}$ and $4\frac{1}{2}$ m.g.d. are used for drinking purposes and in the preparation of food. The Fair water system is built for a peak consumption of 20 m.g.d., has 42 miles of mains which, with fixtures, cost $1,200,000. Cost was borne by the Fair Corp. under an agreement by which the city of New York will furnish water to the Fair in return for acquisition of the 42 miles of mains when the Fair is over and the site becomes a municipal park.

"Oil in the city water" was the cry of a complaining populace in Hillsboro, Illinois. "No," said the superintendent of the water supply.

(*Continued on page 34*)

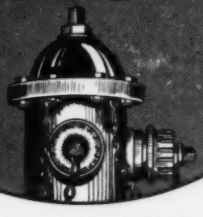
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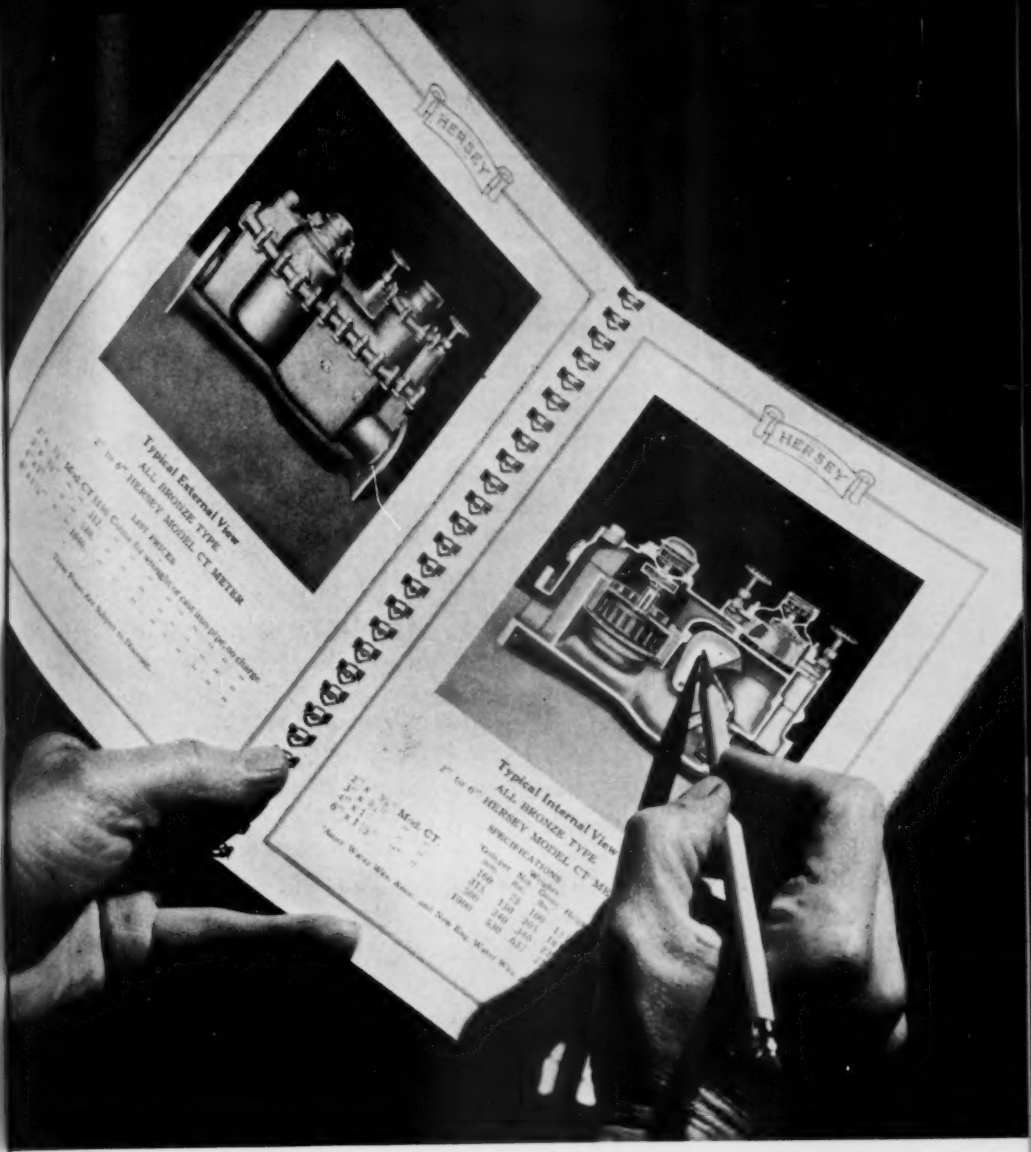
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This is the Counter-balanced Lever Valve, an exclusive Hersey feature that allows the accurate measurements of a wide range of flows. There is no flutter nor loss of accuracy at the Cross-over joint. Meter: bronze single piece case up to 6"—bearing parts non-corrosive—trouble free—low maintenance cost.

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COOK Well Strainers

A reciprocal relation, the life and functioning of the one depending much on the other.

A. D. COOK, INC.
Lawrenceburg - Indiana

COOK Deep-Well Turbine Pumps

(*Continued from page 32*)

It seems the rumor went around town that the powers that be were painting the inside of a new storage tank with oily paint. Immediately a howl of complaint resounded through the town, to which the superintendent replied that the newly painted tank was not yet in service—and furthermore, said the super and the city dads, the consumers will not be told when the new tank *is* put in service.

Rock Island, Illinois, became concerned over its mounting total of delinquent accounts and decided to enforce a local ordinance that would shut off water after accounts were over 50 days due. On the first day after the announcement of plans to shut off water, collections jumped to $1,350 compared with the previous day's collection of $203.93. Enforcement of the ordinance was ordered by the aldermen after they had decided against providing for liens against properties as a method of insuring collections.

The Department of Conservation and the U. S. Geological Survey are cooperating on a water level survey in Indiana to determine the rate at which the water level is dropping. Eighty wells have been under observation in various parts of the state, with daily readings of the water levels reported. Reports from Indianapolis as well as from other parts of the state indicate that water levels were lower in July this year than a year ago. A general survey of the ground water situation in Indiana and the selection of additional wells for checking purposes has been undertaken by C. L. McGuiness of the U. S. Geological Survey, aided by the Division of Geology.

Arguments pro and con for municipal ownership of the water utility in Indianapolis have brought back into the light experience in Kansas City under the Pendergast machine: The following is quoted from the Indianapolis *News:*

"When a city that owns its water utility falls into the hands of crooked politicians, it is possible for the politicians to set up a fictitious engineering corporation and hire it to hunt leaks in the water mains which employes of the water utility already know about.

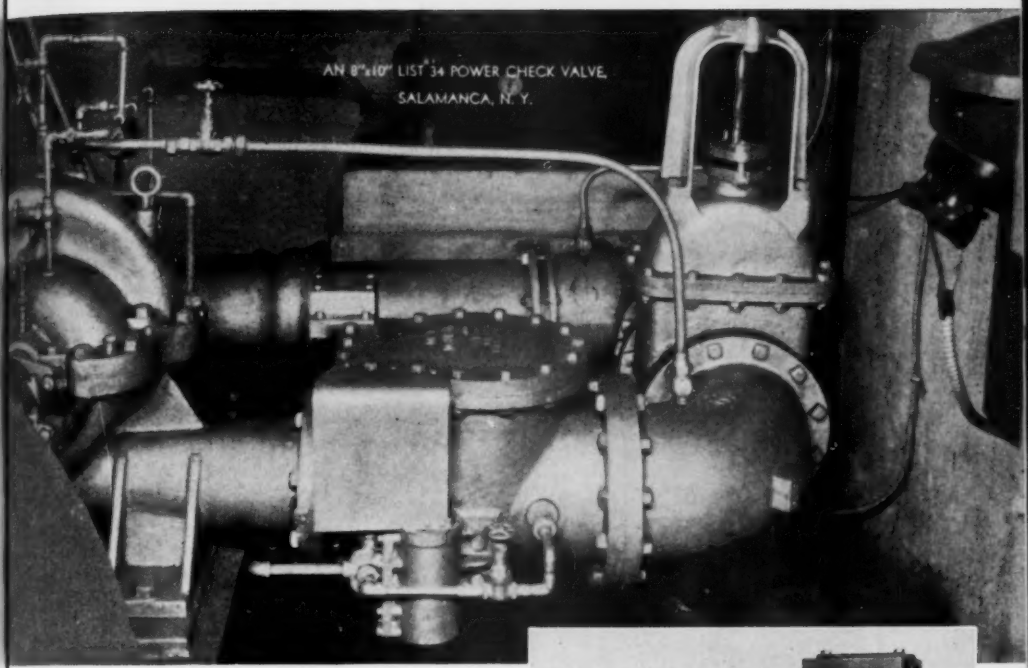
"It is possible to pay such a dummy corporation $5,000 a month, over the protest of responsible engineers in charge of the water plant, and to get away with it to a total of $356,500.

(*Continued on page 36*)

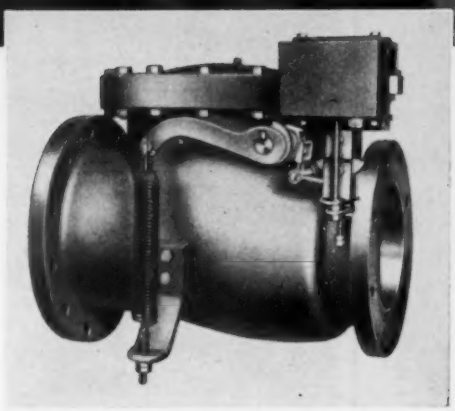
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- **Full clearway opening reduces head loss and cuts power costs.**
- **Simplicity of design and rugged construction results in trouble-free operation over a period of years.**

Bulletin "V" mailed on request

RENSSELAER VALVE COMPANY, TROY, N. Y.

(*Continued from page 34*)

"This is mentioned as a possibility because it happened, according to newspaper and grand jury reports, in Kansas City. It is the method that the Pendergast machine used to get its hands on the revenue of the water utility. It is the reason for the indictment of Henry L. McElroy, former city manager, and officers of the dummy corporation, and for the city's suit to recover the money.

"It is something for a city to think about when it is asked to buy its water utility."

A spheroidal shaped tank for water storage has just been installed at Brookline, Massachusetts. The first of its kind used for municipal water storage, it was chosen by the Brookline Water Board for erection in a high-value residential district because it stands only 47 ft. high. With a diameter of 94 ft., it has a capacity of 1,666,000 gal. storage within a small range of head. The structure looks something like a ball of bread dough flattened considerably by resting on the earth. The tank was designed and built by Chicago Bridge & Iron Co.

(*Continued on page 39*)

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for more than
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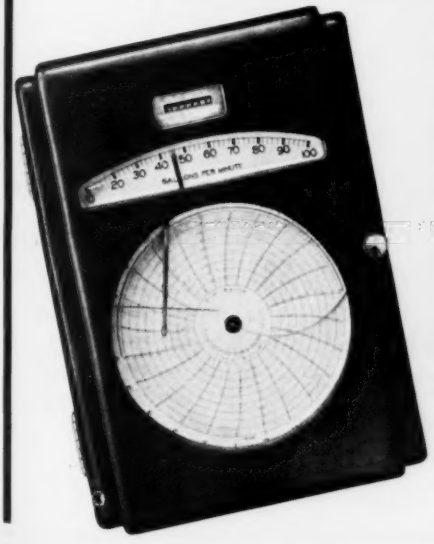
(*Continued from page 36*)

A Canadian municipal works program is going into effect which is in many ways patterned after programs in the U. S. The Federal Government in Canada has made $7,500,000 available on the stipulation that the provinces share the labor costs, with the municipalities contributing the necessary materials. Many cities in Canada are in a very good position financially to take advantage of such a program. For instance, Hamilton, Ontario, has reduced its debt by $8,000,000 in the past four years, and London, Ontario, has cut nearly in two its debt which was $12,000,000 at the beginning of the depression.

Michigan's Lien Law (page 37 of the News of the Field, July, 1939, Journal) is an additional grant of power and therefore applies where local ordinances are already in effect or shall be passed. The bill is designed to aid municipalities in collecting water bills by granting the power to municipalities to place liens on real estate if such procedure is provided by local ordinance. Also: the law does not apply where a lease has been executed providing that the lessor shall not be liable for payment of water bills.

(*Continued on page 40*)

BUILDERS
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FEATURES
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Used with Venturi Tube or Nozzle, Orifice Plate, Kennison Nozzle, Flume, or Weir.

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Write for Bulletin 303-A

BUILDERS IRON FOUNDRY
9 Codding St. Providence, R. I.

(*Continued from page 39*)

A total cost of $64,000 for a revamped water works is announced by Albany, Indiana, which recently put the new system into operation. About a year ago the town paid $24,000 to the private owner for the old system, composed of wells, pumps and distribution mains. A P. W. A. grant for $18,000 was obtained and revenue bonds to the extent of $40,000 were issued as a lien against the water works system. The town has installed facilities for removing iron and lime from the water and has erected a 100,000-gallon standpipe. The town now has four wells with an estimated capacity of ½ m.g.d. each. Total cost to Albany has been $46,000.

"Safe Water" markers are to be erected by the State Health Department at the city limits of Illinois communities which have approved water supplies. The signs will read "Approved Water Supply, State Department of Public Health" and will be placed on posts bearing the name of the municipality. Of the 632 municipal public water supplies in the state, the department has announced that 90 per cent have been approved.

(*Continued on page 42*)

CLEAN YOUR WATER MAINS

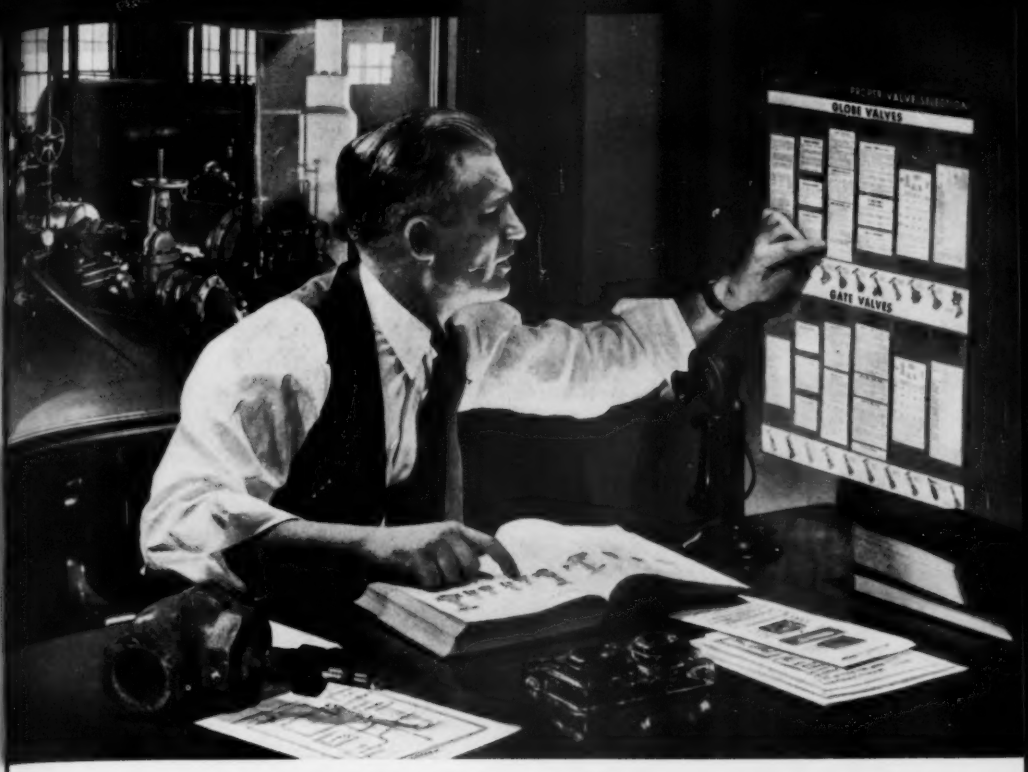
One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

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NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

(*Continued from page 40*)

A. D. Webster, Superintendent, Municipal Water, Sewage, Light and Ice Plant, Orrville, Ohio, died on July 17, from injuries suffered from a fall at the municipal swimming pool. Webster had been superintendent of the local utilities since 1925 and a member of the A. W. W. A. since 1929. He studied electrical, mechanical, and hydraulic engineering at Syracuse University, graduating with top honors. Before going to Orrville, Mr. Webster worked 5½ years at the Westinghouse Electric Company plant at Pittsburgh and from 1921–25 he was chief engineer in charge of motor and control work at the Goodyear Tire and Rubber Company at Akron.

The position that a man like Webster can fill in a small community is best shown by the following editorial which is quoted in full. It is called "Farewell to Al" by Paul L. Powell in the local *Courier-Crescent:*

"Al Webster left us Monday evening. The giver and the taker of that mystery which is life, the Master in whom he had implicit and abiding faith, saw fit to call him away. Although the tens of hundreds of his friends grasped at straws and felt new hope with every word that he had rallied during the illness that followed his injury at the swimming pool Friday evening, it is plain in retrospect that he was fatally injured by the fall. His call had come.

"To say that the community lost one of its most valuable citizens is to do no more than to repeat a phrase that has been uttered verbally by hundreds of residents before this is written. The word "valuable" is not the right word, for, while it indicates the skill that is lost, it does not connote the exceptional clarity of Mr. Webster's mind, nor the unusual integrity of his character.

"Mr. Webster's place as head of the municipal utilities can be filled. He would have been the first to scorn the suggestion that none other was fitted to carry on. We say this despite the fact that there was here as perfect a meeting of a man and a job as life is ever likely to afford. The results of his work here are sufficient testimony to this fact. The plant which he had found when he came as a young man of 30 was a toy; the plant which he leaves is a monument in the making to a trained mind and skilled hands. Because he looked ahead ten years, the plant that is to be is already on paper.

"The loss of his skill which the municipal utilities suffers in his leaving is of no comparison to the loss in honor and integrity which the community suffers. There are only a comparatively few men in each generation who are endowed with the faculty of thinking clearly and of acting upon thoughtful judgment. The loss of even one such man in a generation is a loss that can not be replaced in that generation.

(*Continued on page 44*)

SPRINGFIELD, ILL. A SUCCESSFUL USER OF GENERAL CHEMICAL 'ALUM'



Only three years old, this Springfield, Illinois plant is one of the latest developments, and one of the most successfully operated water softening plants in the country.

General Chemical Aluminum Sulfate is used as the coagulant in connection with the softening process.

Spaulding Precipitators bring about complete softening of the water in less than two hours retention period. Alum and lime treated water after passing upward through the sludge contact blanket is so crystal clear and so stable that long filter runs are obtainable and filtration problems in general are minimized.

The results obtained at Springfield, Ill. are typical of the results obtained in many other plants throughout the country where General Chemical Alum is used. Waterworks men and sewage plant operators are more and more using General Chemical Alum in their plants because it proves superior in tests against other coagulants and because they can count on its high quality and constant uniformity.

Remember: Your technical problems concerning the use of Alum in water purification are ours.

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GENERAL CHEMICAL ALUMINUM SULFATE

(*Continued from page 42*)

"Mr. Webster had the great capacity of seeing things in their proper relation to the whole. Aloof from the trivialities of life which vex most of us so sorely and make our days a succession of defeats, his mind reached to the nub of matters. Uncluttered with petty grievances, with fancied wrongs, with jealousy or self-seeking his mind could and did devote its exceptional power to considering that which was pertinent and vital in all things.

"It is no exaggeration to say and we slight none in saying that Mr. Webster had one of the two or three best minds in the community. It was an engineer's mind—keen and analytical. It was not petty, nor did he allow it to become subordinate to his feelings. He sought the truth and, having found it, let the truth stand naked. He did not need to cloak truth to be able to live with it.

"One of our friends commented on the fact that although none of us had been 'close' to Mr. Webster in the sense that we saw him frequently and conversed with him often, his death brought home the fact that his life had deeply touched ours. That is not odd, for we think that the keeness of his perception, the purity of his motives, the ingrained honor that cloaked him as an armor, like a surgeon's scalpel, cut deeply into the consciousness of those who knew him.

"That this is true was indicated by the great outpouring of tribute that was in evidence last night. From every walk of life, of every creed and shade of faith, from the lowliest placed to men of large attainment, they came to say goodbye. To live so that one shall tug at the hearts of men so strongly when the fragile silver thread that binds us to this life is broken is to live divinely.

"Although our loss is irreplaceable, and that is too bad for in this day we lack strong and supple minds that do not bend with every breath of popular fancy, nor need to curry popular favor, we have the consolation that Mr. Webster was ready to embark on any journey that his Lord could ask. He never feared living. He met his friends and business foes with a lance that was sharpened well and was in perfect balance. Such men do not fear death. They meet its challenge with a smile, knowing that at last they are privileged to penetrate the veil that hides the one unfathomable mystery of the universe."

Charles H. Morris, Supervisor for the last 24 years of the New Brunswick, N. J., Water Department, died on July 20 at the age of 74. He was at one time President of the New Jersey Water Works Association and he was a member of the A. W. W. A. since 1916.

NEWS OF THE FIELD

"This liberty will look easy by and by when nobody dies to get it!" These words from the character of George Washington in Maxwell Anderson's *Valley Forge* are again being proven true by the conflict now disrupting the western world. Spoken in the play at a point of great discouragement to the colonists, they signalize the resolution to continue the struggle in the face of strong opposition from without and sabotage within.

There is no call here to analyze the underlying causes of the present conflict. They revolve about conflicts centuries old and not easily reduced to simple terms.

But the uses of the words "Democracy" and "Dictatorship" do call for some thought from all of us in America so that we do not hold too lightly the responsibilities which our liberties place upon us.

In a society where the rights of the individual are held most important, it is vital that those same individuals do not forget that by their uses of those rights the citizens justify or nullify them.

Democracy—whatever it is—did not spring full fledged from nature. It does not exist as something to be put on as one puts on a coat. It is a way of living and can be lived as well as passed on to later generations only as those who enjoy its values today show themselves worthy of its values.

A nation of little men, of selfish men, of dishonest men can in this generation destroy the democracy and liberty it has taken half a millenium to establish. And by the use of the word "nation" is not meant its president and its senators but its common people, its city leaders and those who serve the city and state in positions of responsibility.

Water works men, as a part of that widely spread organization of public services, owe to themselves, as well as the people they serve, a calm consideration of the part they play in making the American way of life effective. Petty graft, inefficiency and self seeking have no place in that scheme of things. Honest leadership, hard work and devotion to the tasks entrusted to men will preserve liberty and democracy. Whether a man be a meter reader or a manager, a member of the maintenance crew, or the comptroller, a shift operator or a superintendent—that man will preserve to himself the blessings of a free people by doing his work well and intelligently.

Liberty is not easy to get and is still harder to keep.

(*Continued on page 2*)

(*Continued from page 1*)

Michigan has approved water supplies in every town of 1,000 or more population, according to a report of the State Health Department of that State. Having obtained this objective, the Department announces, it will go on to a campaign for the elimination of objectionable tastes in public supplies, the reason being that such tastes often cause consumers to use polluted private supplies. The State Health Department has also staged a drive to safeguard ground water supplies used in rural areas, in cabin and trailer camps, and in camps and cottages. The Department has developed a tentative standard which it is seeking to have observed throughout the state. The tentative standard requires adequate drainage on the surface of a site for a water source, freedom from floods, reasonable removal from areas in which underground construction is located, and satisfactory earth formations.

The American Municipal Association has announced the appointment of Earl D. Mallery as Executive Director to succeed Clifford W. Ham, recently deceased. The Association maintains its headquarters in Chicago in the Public Administration Clearing House Bldg. at 1313 E. 60th Street.

Thomas M. Lowe, formerly Associate Professor of Civil Engineering at the University of Florida, Gainesville, Fla., is now Head Professor, Department of Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. Prof. Lowe was chairman of the Florida Section from 1938 to 1939.

(*Continued on page 4*)

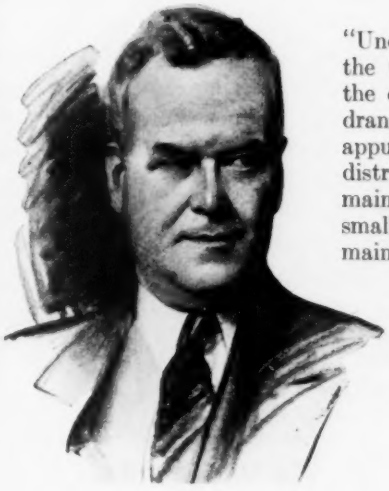
David Rhett Pringle, Superintendent, Water and Light Department, Thomasville, Ga., died August 3, after a long illness. Mr. Pringle was born in Florida, but his parents later moved to Thomasville, where he attended private schools. He took a degree in electrical engineering with high honors at Georgia Tech in 1904 and then worked in the New York and St. Louis offices of the American Telautographic Company until the latter part of 1905. In November of that year, the municipality of Thomasville decided to purchase the electric light plant serving the city, and Mr. Pringle was chosen to superintend operation of the plant. Later he was also Superintendent of the water plant.

Mr. Pringle was a member of the A. W. W. A. for the past 15 years and was chairman of the Southeastern Section in 1937–38. He also has been president of the Georgia Light Plant Association.

B.W.CULLEN

(Supt. Water Pipe Extension, Chicago Water Dept.)

says



"Under the head of maintenance expense, the Chicago Water Department includes the cost of repairing mains, services, hydrants, valves, meters and, in general, all appurtenances that have to do with the distribution of water. The actual cost of maintaining the MAINS ONLY is very small, even though some of these cast iron mains, of which we have in all 3776 miles, are as much as fifty years old. In thirteen miles of 24″ to 48″ mains for which definite records were examined, some laid as far back as 1881, the actual cost per mile, per year, on the average was $5.93."

B.W. Cullen

Water mains represent about one-third of this country's 5-billion-dollar investment in public water supply systems. More than 98% of these mains are cast iron pipe with a *known* useful life at least double the *estimated* life of other water main materials. Because the tax-saving, through deferred replacements alone, is enormous, cast iron pipe is known as Public Tax Saver No. 1.

CAST Q IRON

Look for the "Q-Check" Registered trade mark.
Cast iron pipe is made in diameters from 1¼ to 84 inches.

The Cast Iron Pipe Research Association, Thos. F. Wolfe, Research Engineer, 1015 Peoples Gas Building, Chicago, Illinois

CAST IRON PIPE
PUBLIC TAX SAVER NO. 1

(*Continued from page 2*)

Colonel Theodore A. Leisen, for the past 16 years General Manager of the Metropolitan Utilities District, Omaha, Nebraska, has resigned from that position. Col. Leisen is a former President of the A. W. W, A. and has been a member since 1904. Walter S. Byrne, an engineer and most recently Vice-President and General Manager of Thomas Kilpatrick & Co., store of Omaha, will succeed Col. Leisen. Willis J. Barber, who has been with the utilities district since 1900 will continue as Assistant Manager.

Col. Leisen was born in Philadelphia, Pa., in 1864. After leaving high school, he pursued special studies in engineering under the guidance of two former professors of engineering of the defunct Polytechnic College of Philadelphia and at the same time obtained practical experience on general surveys and railroad location. In 1883 he served as Assistant Engineer in the Engineering Department of the City of Wilmington, Del., and later in the same year went to South America as Assistant Engineer, on location and construction, for the Ferro Carril de Antioquia, Republic of Colombia. He was transferred in 1886 to the Barranquilla Railway and Pier Company in Barranquilla, Puerta Colombia, where he was

(*Continued on page 6*)

3 *Money, Time and Labor Saving Features of*

UNIVERSAL CAST IRON PIPE

LAID WITH ONLY WRENCHES →

NO CAULKING MATERIALS →

NO GASKETS. NO BELL HOLES TO DIG. NO LEAD →



For water supply, fire protection systems, sewage disposal systems, industrial, and irrigation. Tight joints.

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RUSTOP *the*

Cathodic Method of Eliminating and Preventing Rust and Corrosion in Steel Water Tanks.

Eliminates the Necessity of Painting below the Overflow.

Now Used by Many Cities And Manufacturers. Write For List Today.

Cleans Old Tanks. Keeps New Tanks Clean.

(Pat. Pend.)

ELECTRO RUST-PROOFING Company
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Dayton, Ohio

Permutit Spaulding Precipitator



New Cold Lime Treatment Makes Good!

Spaulding Precipitator installations are breaking records . . . more than 20 plants within the last few months ... ranging in capacity from 5,000 to 8,000,000 gallons per day! Two features: 1. *Sludge is kept suspended*—this speeds precipitation, also acts as a contact filter. 2. *Conical filter-chamber*—this lowers velocity as water rises. Sludge drops out, leaves effluent sparkling.

NOW GET SOFT, IRON-FREE WATER . . . ECONOMICALLY!

Now there's little excuse for *any* city having to put up with unsatisfactory water. For the Spaulding Precipitator not only takes less than half the space needed for old design chemical plants . . . it also makes startling new economies!

Less chemicals are needed, for one thing. For another, water is so stable that recarbonation is often unnecessary. Here's something it will pay you to investigate immediately!



16-PAGE BOOKLET FREE! The full story of Permutit Spaulding Precipitator ... diagrams, layouts, actual installations. No obligation . . . address The Permutit Company, Dept. G2, 330 West 42nd St., New York.

PERMUTIT

WATER CONDITIONING *Headquarters*

(*Continued from page 4*)

Assistant Engineer on the location and construction of an extension of the railroad to the Company's ocean terminal, and later was Chief Engineer in charge of terminals, a position from which he resigned in March, 1890.

After traveling in England and France, he returned to Wilmington, Del., in June, 1890 to become Assistant Engineer on the design and construction of the sewer system. From 1893 to 1903, he served as Chief Engineer of the Park Department of Wilmington, designing roads, bridges, and miscellaneous park works. During the latter part of this period, he also served as consulting engineer for the Water Department. From May, 1904 to July, 1908, he was Chief Engineer of the Water Department, in full charge of the design and construction of filtration plants, pumping stations and reservoirs.

In August, 1908, he was appointed Chief Engineer of the Louisville Water Company, with headquarters in Louisville, Ky., in which position he served until April, 1914 when he went to Detroit to become General Superintendent of the Detroit Water Board. He remained there in active charge until October, 1917, when he was commissioned a major in the Construction Division of the U. S. Army and assigned to Camp Custer,

(*Continued on page 8*)

OVER 500 municipalities use American or New York Continental Jewell Water purification equipment.

WATER FILTERS
WATER SOFTENERS

Proportionate Electro-Magnetic Chemical feeders for feeding lime, acid, alum, soda ash, etc.

AMERICAN WATER SOFTENER COMPANY
Lehigh Avenue and 4th St.
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Cathodic Protection
for
Steel Water Tanks

ELIMINATE
Rusting
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below the water line.

Guaranteed to save its cost at least *once every four years.*

RUST-O-RESTOR TRADE MARK REGISTERED
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FREMONT, OHIO



Fortunately, in these modern times, you haven't far to look for pressure pipe that is non-corrosive, and non-tuberculating and electrolysis-proof in addition. Asbestos-Cement pipe is saving thousands of dollars annually for many a water works by eliminating these costly and familiar pipe diseases. Maintenance costs are drastically cut, as well as pumping costs and pipe replacements.

With the introduction of "Century" Asbestos-Cement Pressure Pipe, you can get these advantages in a pipe that has exceedingly high and uniform strength, insuring unusually long service life. Each length must pass a series of searching tests before it is released for shipment. Providing further economies, this pipe is easily handled and laid because of its light weight.

"Century" Asbestos-Cement Pipe is a product of the Keasbey & Mattison Company, pioneers in the development of Asbestos and Asbestos-Cement products. It is produced by a remarkable new manufacturing process which produces an exceptionally strong and uniform pipe.

FREE "Mains without Maintenance," the new catalogue on "Century" Asbestos-Cement Pipe. Get all the facts.

See K & M's Fiery Snowman and Exhibit in the Home Building Center at the N. Y. World's Fair.



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District Sales Offices in Principal Cities

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Send me, without obligation, free catalogue on "Century" Asbestos-Cement Pressure Pipe—"Mains without Maintenance."

NAME _____

NAME OF PLANT _____

ADDRESS _____ JAWWA-3

(*Continued from page 6*)

Mich., as Utilities Officer and Constructing Quartermaster. He was later commissioned Lieutenant-Colonel and Colonel, O. R. C. In addition to the routine work at Camp Custer, he constructed the second addition to the camp, at a saving of two million dollars compared with the cost estimated by the government.

Upon discharge from active duty in the Army in June, 1919, he returned to Detroit to become Consulting Engineer in charge of the design and construction of the filtration plant and pumping station, where he remained until the completion of the work in 1923. In November, 1923, he was appointed General Manager of the Metropolitan Utilities District of Omaha, Neb., having in his charge the entire construction and operation of the water works, gas plant and municipal ice plant.

Besides serving as President of the A. W. W. A. in 1918, Col. Leisen has been Vice-President of the Association in 1912, '13 and '17; he was a trustee in 1914–16 and 1927–29; a member of the Executive Committee in 1919 and 1920. He was made an honorary member of the A. W. W. A. in 1938. Col. Leisen has also been active in the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the Omaha

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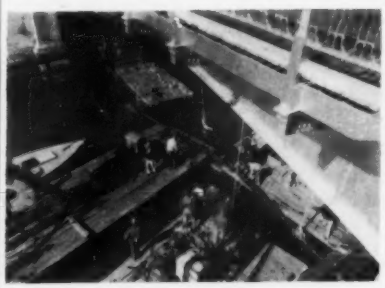


PHOTO shows 8" Molox Ball & Socket Pipe being jointed together prior to lowering into 23 feet of water in ship channel under "Bridge of Lions" across Matanzas River, St. Augustine, Fla., as a water supply main operating at 50 lbs. pressure. Molox Ball & Socket Pipe was selected because of its exceptional physical strength properties, adaptability to submarine installation, and extreme joint flexibility which allows for any normal movement of pipe caused by tide, passing boats, etc. Write for literature.

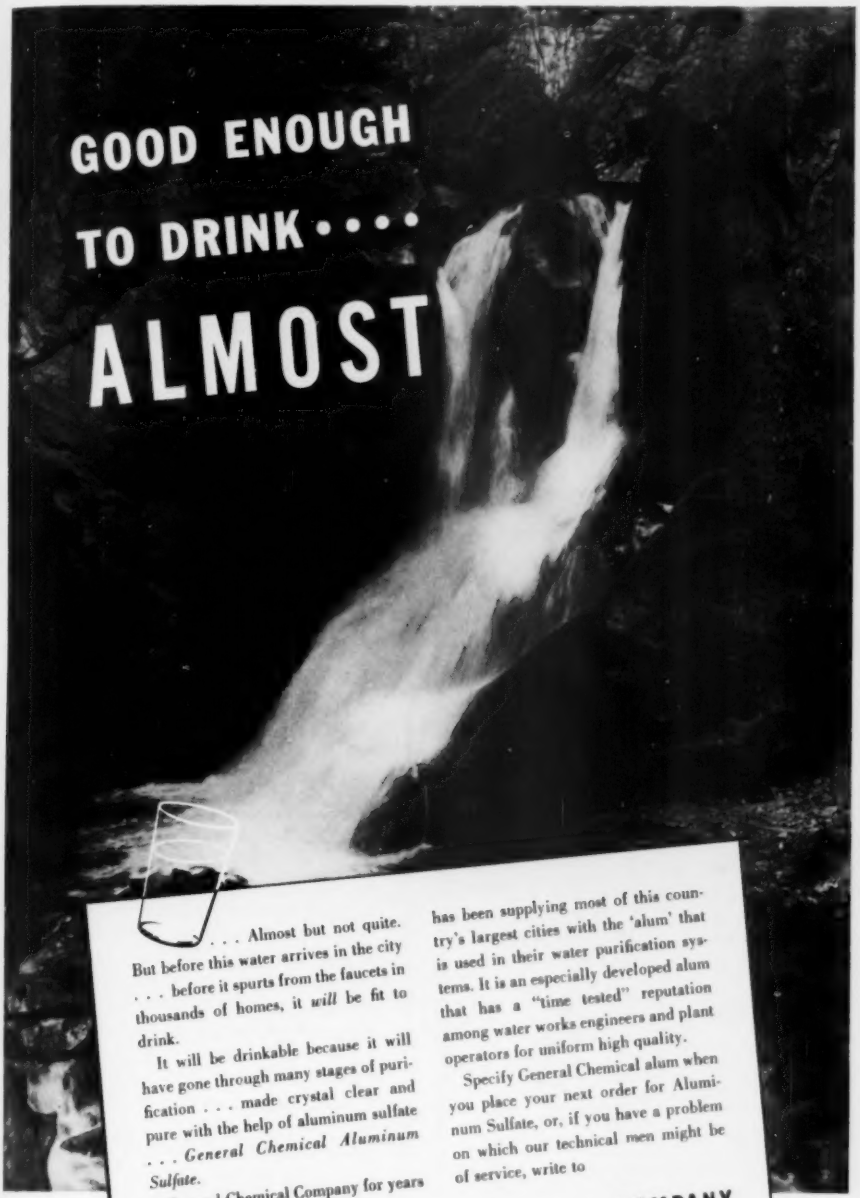
American Cast Iron Pipe Co.
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ANY OLD JOURNALS FOR SALE?

Do you have back issues of the Journal which you will make available to the Association to help replenish its stock? Send a post card telling which you have of the numbers listed below and 50¢ will be paid for each copy obtained.

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1924—January, May, July, September
1926—January, May, June, September, November
1929—January
1936—April
1937—January, February, March
1938—January

American Water Works Association
22 East 40th St., New York



. . . Almost but not quite. But before this water arrives in the city . . . before it spurts from the faucets in thousands of homes, it *will* be fit to drink.

It will be drinkable because it will have gone through many stages of purification . . . made crystal clear and pure with the help of aluminum sulfate . . . *General Chemical Aluminum Sulfate.*

General Chemical Company for years has been supplying most of this country's largest cities with the 'alum' that is used in their water purification systems. It is an especially developed alum that has a "time tested" reputation among water works engineers and plant operators for uniform high quality.

Specify General Chemical alum when you place your next order for Aluminum Sulfate, or, if you have a problem on which our technical men might be of service, write to

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GENERAL CHEMICAL COMPANY **ALUMINUM SULFATE**
A BASIC 'ALUM' CONTAINING NOT LESS THAN 17.0% AVAILABLE Al_2O_3

(*Continued from page 8*)

Engineers Club. He is an honorary member and former president of the Engineers and Architects Club of Louisville, Ky.

Maryland has joined the list of states which register all professional engineers and land surveyors. The Governor has appointed the Board of Registration which includes S. T. Powell as one member and Prof. A. G. Christie of Johns Hopkins as chairman. Powell is widely known among A. W. W. A. members as a consulting engineer in boiler feedwater treatment problems. He was formerly the head of the inter-association Joint Research Committee on Boiler Feedwater Studies.

James E. Specht, formerly of the Hagan Corporation, has been named Superintendent of the Orrville, Ohio, Municipal Utilities, to succeed the late A. D. Webster. Mr. Specht, who is only 32, will be in charge of the four municipal utilities—electric power plant, ice plant, water system and sanitary sewer system.

Mr. Specht was born at Anoka, Minnesota, in 1907, and graduated in 1929 from the College of Electrical Engineering, University of Minne-

(*Continued on page 12*)

For Underground Service Lines

ANACONDA COPPER and RED-BRASS



Anaconda Copper Tubes in straight lengths and coils... Anaconda "85" Red-Brass in straight lengths only — both are products of dependable quality. Made by the world's largest and most experienced manufacturer of copper and brass, and stocked by leading supply houses.

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General Offices: Waterbury, Connecticut

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Tegal-MINERALEAD brings you the advantages of sulfur base compounds without their drawbacks • Initial leakage is greatly reduced, permitting quick back filling and clearing up of traffic hazards • Makes permanently tight seal amply able to withstand any strain it is likely to meet in service • The 10 lb. ingot form is convenient to handle, ship and store—and is impervious to water damage; also it cannot change composition in transit—reaches you exactly as mixed at plant. • Write for further information.

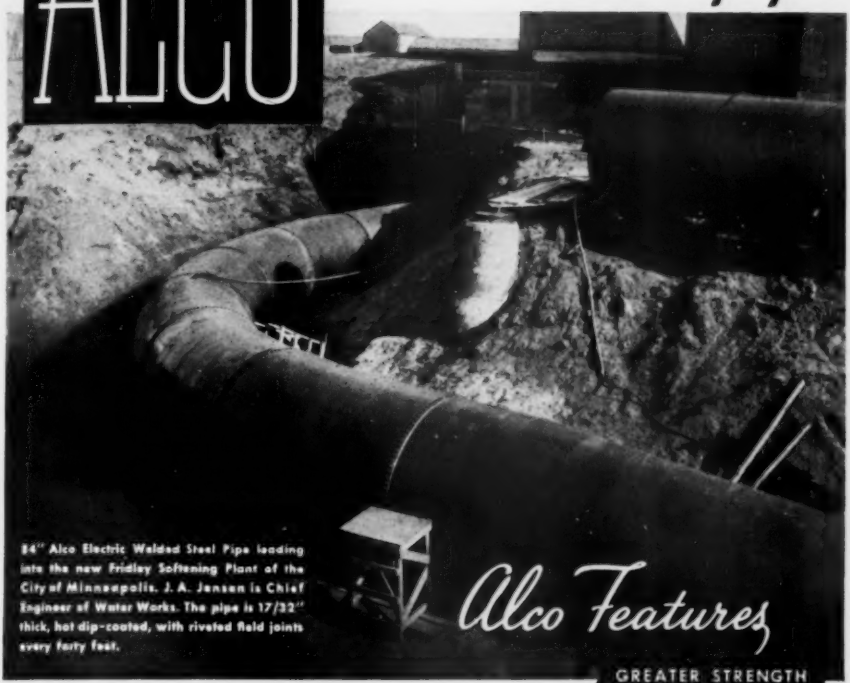
A Tegul PRODUCT

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ALCO

ELECTRIC WELDED *Steel pipe*



84" Alco Electric Welded Steel Pipe leading into the new Fridley Softening Plant of the City of Minneapolis. J. A. Jensen is Chief Engineer of Water Works. The pipe is 17/32" thick, hot dip-coated, with riveted field joints every forty feet.

Alco Features

GREATER STRENGTH
LONGER LIFE
SMOOTHER WATERWAY
LONGER LENGTHS
FEWER FIELD JOINTS
LOW INITIAL COST
ULTIMATE ECONOMY

• Since 1897 Minneapolis has been using steel pipe and now has more than 200,000 feet of it over 30" in diameter in water works and sewage service. All this pipe is in excellent condition. The maintenance cost during 41 years of service has been practically nil—no breaks, no shutdowns for repairs.

Why not be guided by the experience of this progressive city?

ALCO PRODUCTS

DIVISION OF

AMERICAN LOCOMOTIVE COMPANY
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AMERICAN LOCOMOTIVE SALES CORP.
INCORPORATED IN U.S.A. WITH LIMITED LIABILITY
ARTILLERY HOUSE, ARTILLERY ROW, LONDON, S. W. 1, ENGLAND

(*Continued from page 10*)

sota, with the degree of Bachelor of Electrical Engineering with Distinction. From 1929 to 1931 he was employed by the Westinghouse Electric and Manufacturing Co. at East Pittsburgh, Pa., serving there in the machine shop and in the high voltage and photo-electric laboratories. Since 1931 his duties with the Hagan Corporation were along the line of design and research for electric and pneumatic control of boilers and furnaces. Mr. Specht has been a resident of Orrville for the past eight years and has served as consultant on the operation of the Hagan combustion control equipment at the Orrville power plant.

Centralized measurement and control are described in detail in a 12-page booklet issued recently by The Foxboro Company. The bulletin gives the fundamental functions of individual instruments as well as simplified overall schematic plant layouts showing application of such control systems. This booklet, No. 233, obtainable from The Foxboro Company, Foxboro, Mass., explains systems of flow measurement, flow control, liquid level, loss of head, pressure and altitude, and temperature measurement.

(*Continued on page 14*)

EDSON
DIAPHRAGM PUMPS

Hand Operated—size 2″, 2½″, 3″, 4″
Power Operated—size 3″ and 4″
Open Discharge or Force Pump
Skid, Truck or Trailer Mounted

Complete Pump Outfits, Genuine Edson Pumps, Suction Hose, Brass Couplings, Bronze Clamps, Red Seal Diaphragms, Brass Strainer or Foot Valve, Hose Spanners, Adapters, Etc. Brass Hydrant Pump.

THE EDSON CORPORATION
Main Office and Works: 49 D St., South Boston, Mass.
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WHITE
FILTER SAND
98% Pure Silica

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Washed, Screened and Dried. No Freight on Moisture—Prompt shipment in Bags or paper lined Box Cars—Write or wire us for information and prices.

DAWES SILICA MINING COMPANY
Silica Mines
THOMASVILLE, GEORGIA

Squared Masonry for Rome...



50 A.D.

The ruins of the Claudian Aqueduct finished in 50 A.D. are a monument to the engineering genius of Emperor Claudius and his men. Of squared masonry construction, this 44-mile conduit carried spring water to the fountains and baths of ancient Rome.

Electric-welded pipe for Cleveland...

1939 A.D.

Part of a shipment of electric-welded pipe supplied by Bethlehem for the Brookpark Road water main in Cleveland, Ohio. Bethlehem has furnished steel materials for many of the country's prominent water systems.



While ancient aqueducts took years to build, Bethlehem moves swiftly and smoothly as a manufacturer and supplier of electric-welded, spun-enamel-coated pipe. Both fabricating and steel-making divisions are closely knit parts of the same company and function as a unit. As a result, needless time and labor losses can be eliminated and contracts completed well within the specified time limits.

BETHLEHEM STEEL COMPANY

(*Continued from page 12*)

New Materials and Gadgets

1. A new cooler for diesel engine jacket water operates in a closed system and so makes possible recirculation of the jacket water and a consequent reduction in makeup water. Soft water can be recirculated through the coil to the engine, thus eliminating precipitation of hard water minerals on the cooling surfaces. The cooler is for indoor or outdoor use.

2. A new ferric coagulant has been put on the market which is claimed to be stable in storage and completely soluble in cold water, and not to lose or take up water in storage.

3. Detection of abnormal noises from a machine is said to be accomplished by a new device which will thus inform an operator of impending trouble before a machine breaks down.

4. A tracing paper, claimed to have the permanency of 100 per cent rag stock but as transparent as oil-treated paper, has been put on the market. It is treated with a new substance, no oil or wax being used, and is said not to become yellow or brittle with age.

5. A photo film preservative has been developed to be applied in liquid form to the emulsion side of finished photographic film, thus to toughen the film against cracking or scratches.

6. A small arc-welding machine for use on construction jobs, in garages and in shops is now available. Its net weight is 320 lb.

7. A decalcomania item has been produced which bears the useful decimals, equivalents, etc. It is made to fit the T-square or may easily be placed elsewhere near at hand.

8. Interchangeable windows are a feature of new face shields on the market. Screen, fiber, and plastic windows are provided with each shield.

Readers can obtain further information by sending a postal to the A. W. W. A. headquarters giving the reference numbers of any of the above items and citing the September issue as the source.

(*Continued on page 16*)

Does "October 17 to 20 in Pittsburgh" Mean Anything to You?

To SOME 3,000 PROFESSIONAL PUBLIC HEALTH WORKERS all over the country who have made their plans to attend the 68th Annual Meeting of the American Public Health Association and meetings of related organizations it means a great deal.

IT MEANS THE GAINING OF A NEW PERSPECTIVE on public health progress in the United States; it means stimulation and encouragement for the months ahead; it means new ammunition for the solving of old problems and for attack on the new; it means identification with public health workers who are doing important things and thinking about a more important future.

IT MEANS, IN SHORT, THE ANNUAL MEETING of the American Public Health Association, where those who guide the nation's health come together in what has been for nearly three-quarters of a century the most distinguished and significant health conference of the year.

ARE YOU ONE OF THE 3,000? If you are, the summary of the scientific program in the August issue of the American Journal of Public Health will prove how right is your decision to be present. If you are not, a reading of the program summary will show you that you cannot afford to stay away. A reprint will be sent on request.

AMERICAN PUBLIC HEALTH ASSOCIATION

50 West 50th Street New York, N. Y.

(*Continued from page 14*)

Standardization activities are at a peak among the associations which deal with such matters, and many projects under way for some time have reached, or are now reaching, completion. A. S. M. E. has announced the completion of several A. S. A. joint specifications in the field of pipe and fittings. Among these are:

Malleable Iron Screwed Fittings (B 16c-1939) for working Saturated Steam Pressure of 150 lb./sq.in.

Steel Ppie Flanges and Flanged Fittings (B 16e-1939) for pressures from 150 to 2,500 lb./sq.in.

Cast Iron Pipe Flanges and Flanged Fittings (B 16a-1939)—class 125.

Copies of these specifications can be obtained from the A. S. M. E. priced at $0.50, $1.25 and $0.60, respectively. Water works men engaged in mechanical plant design and maintenance should use these documents as guides to purchase items described therein.

Local Government Debt Administration is a new book by Carl H. Chatters, Executive Director of the Municipal Finance Officers' Assn, and

(*Continued on page 18*)

"K-CO" *Quality* BRASS GOODS FOR "K-CO"

WATER COMPANIES



C-101. Tee Handle Stop Roundway

Inverted Key Curb Stops, Corporation Stops, Tee and Lever Handle Stops and Stops & Wastes, Water Meter Couplings and other Fittings for Water Works usage are made by Kitson of high grade brass—accurately machined and tested for tightness.

Send for Catalog E



C-103. Tee Handle Stop and Waste Roundway

KITSON COMPANY
2409-15 Westmoreland St., Philadelphia, Pa.
Manufacturers of Kitson Safety Devices (Lovekin Patents) for Domestic Water Heaters . . . Quality Brass Goods for Gas, Water and All Plumbing Uses.

Save the Cost of Breaks and Leaks

In Water Supply Lines



Why put up with the high cost of leaks and breaks in water supply and force mains? Now you can eliminate most of this trouble and expense by using Armco Spiral Welded Steel Pipe.

With Armco Pipe there's no danger of sudden breaks since the steel used has an ultimate specified strength of 50,000 to 60,000 pounds per square inch. Then too, it "stretches" 25 to 30% before the breaking point is reached. In addition, Armco Pipe assures strong, water-tight joints that hold costly leaks to a minimum. When properly installed, Armco Spiral Welded Pipe keeps its line in spite of frost action, shifting soils or heavy traffic impact.

Write for complete information illustrating the many other practical advantages of Armco Spiral Welded Steel Pipe for water supply lines and force mains. The American Rolling Mill Company, Pipe Sales Division, Executive Offices, 351 Curtis Street, Middletown, Ohio.

ARMCO

ARMCO SPIRAL WELDED PIPE

APPROVED BY UNDERWRITER'S LABORATORIES, INC.

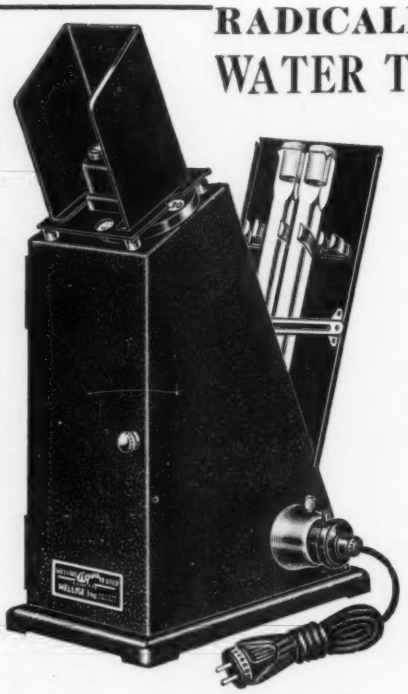
(*Continued from page 16*)

Albert M. Hillhouse, Professor of Economics at Davidson College. The book is written as a constructive treatment of the subject about which there is so much discussion but so little concrete information. The authors' purpose is to tell *how to sell bonds* to the best advantage and to tell *how to administer the debt* once it has been created. The chapter on long term financial planning is a treatise on how to avoid unnecessary debts. The book was written to be a practical manual for public officials, as a guide for interested citizens and as a text for students of government. It is a book of 528 pages, published by Prentice-Hall, Inc., New York, N. Y., and priced at $5.00.

A pipe installation machine that is completely hydraulic in operation has been designed by the Jasonville Water Company, Jasonville, Ind. W. A. Oeffler, Superintendent of the Jasonville plant, reports that the machine is designed to push or pull with equal force, has two speeds, is manually operated, and is compact, weighing less than 200 lb.

Water Tasters are premature in their complaints at Lansing, Mich.,

(*Continued on page 20*)



RADICALLY IMPROVED
WATER TEST COMPARATOR

The new Hellige Aqua Tester combines the thoroughly demonstrated advantages of Hellige *non-fading glass color standards* with radical improvements in design. This new model is, we believe, the most advanced type ever brought on the market and demands special consideration as it brings to its user the utmost in permanent reliability, accuracy, convenience and, last but not least, economy. Standards for all popular A. P. H. A. and A. W. W. A. Methods and Hydrogen Ion Control are available.

Write for Bulletin No. A-611.

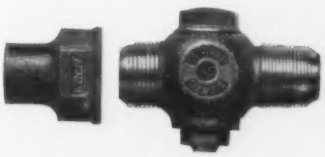
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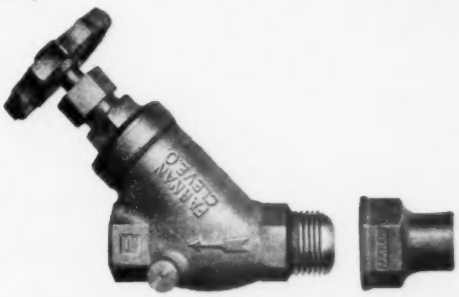
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FARNAN

MORE

Quality
Service
Dependability
Satisfaction
Experience
Durability





THE BEST OBTAINABLE AT ANY PRICE



THE FARNAN BRASS WORKS CO.

Cleveland **Ohio**

Est. 1852

(*Continued from page 18*)

where a new treatment plant is under construction. Otto E. Eckert, Superintendent of the Board of Water and Electric Light Commissioners, has reported receipt of complaints from residents who object to the taste of the water from the new plant which will not go into operation until October.

Water softeners are to be sold and installed in the homes of consumers by the local governments in Warren and Bluffton, Ind. Each installation in Warren will be made at an estimated cost of $20 to $25. Arrangements are being made to allow payment in installments and each installment will be added, along with a monthly charge of 50 cents for re-charging, to the regular monthly water bill.

Payment for sewage disposal in Detroit is planned by levying a charge of 19½ cents for each 1,000 cubic feet of water used by customers of the Department of Water Supply. The plan is to bill customers separately and for this operation new billing machines costing about $45,000 are needed. This charge is planned to meet an estimated annual operating

(*Continued on page 22*)

A. W. W. A.
Membership Certificate

A fine newly designed parchment paper membership certificate for A. W. W. A. members is now available in 9 by 12 inch size, suitable for framing.

Give us your name—exactly as you wish it to appear. Send 40¢ in coins or postage to cover cost of lettering and mailing.

The certificate will reach you within 10 days of receipt of order —ready for you to frame and hang in your office.

"Why don't you tell them...?"



We received a letter recently from an old customer. We like its blunt, constructive criticism—its straightforwardness, and, of course, its praise.

"Now that you have asked us, we, in this department, think that your advertising is too conservative. True, you have explained why the Empire Meter is accurate on both large and small flows, why its accuracy is sustained, why it stops less, sticks least, but—

"Why don't you tell them, straight from the shoulder, that for better than fifty years no other water meter ever made has even approached the Empire in maintained accuracy. It's the cheapest meter in the long run. Our records prove it—you can refer to us."

We have records, too—reports on performance of Empire Meters. We would like to show them to you, not as "proof," but because we believe that they will simplify your selection of meters.

NATIONAL METER COMPANY
4207 First Avenue, Brooklyn, N. Y.
BOSTON • CHICAGO • DALLAS
LOS ANGELES • SAN FRANCISCO • SEATTLE

NATIONAL *Meters*

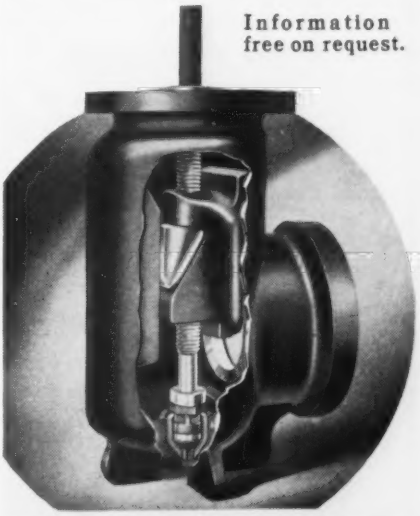
THE BEST *Hydrant* PROVIDES *Easy Inspection*

A hydrant must allow easy inspection and servicing. The ***best*** hydrant, therefore, permits the removal of ***all*** working parts as ***one unit*** by lifting stem through top of hydrant, ***without unscrewing anything below the ground level.***

The best hydrant also provides ***quick*** water with least possible shock, and shut-off without water hammer. It is properly drained at the ***lowest*** point. It will not flood when broken, because the gate is wedge-locked.

Only the slide gate principle provides ***all*** these advantages. This principle, developed and perfected by Ludlow, has been the universally accepted construction in all ***water works valves*** for nearly three-quarters of a century. It likewise insures ***complete security*** in fire hydrants.

Information free on request.



The LUDLOW VALVE MFG·CO· SINCE 1866 TROY·N·Y·

(*Continued from page 20*)

cost of $850,000 and to pay off, over a period of 30 years, sewage works bonds totaling $5,075,000.

In its campaign against waste, the Illinois Central Railroad System has set forth the cost of supplies and equipment in terms of income from a unit of goods produced, in this case revenue per ton of freight per mile. For example, a staybolt wasted is the wasting of the income from 56 tons of average freight hauled one mile; one boiler tube, 364 tons of average freight one mile; one gallon of oil, 57 tons of average freight one mile; one typewriter ribbon, 28 tons of average freight one mile; one coal scoop, 118 tons of average freight one mile. Many other examples are given so that employees in every department can gage the cost of waste in terms of work done. Here is an idea for a savings program that could be instituted in a water works plant by translating the waste of materials and supplies into terms of income per 1,000 gal. of water sold.

Industrial Standardization, publication of the American Standards Association, has in its July and August issues two excellent articles de-

(*Continued on page 26*)

BUILDERS
Flo-watch



FEATURES and SPECIFICATIONS

Simple, compact, mechanical flow meter, guaranteed accurate over wide flow range.

Used with Venturi Tube or Nozzle, Orifice Plate, Kennison Nozzle, Flume, or Weir.

Attachment for remote registering dials and automatic proportional operation of chemical feeders available.

Ample mercury and large float provide adequate power for permanent accuracy and low maintenance.

Panel, wall or floor stand mounting (opening for panel mounting 12¾" wide x 19½" high).

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Cleveland	Rockefeller Bldg.	Philadelphia	1700 Walnut Street Bldg.
Dallas	Liberty Bank Bldg.	San Francisco	Rialto Bldg.
Detroit	Lafayette Bldg.	Tulsa	Hunt Bldg.

Plants at BIRMINGHAM, CHICAGO and GREENVILLE, PA.

(*Continued from page 22*)

scribing the scope and results of standardization activities of federal government agencies. The author, John H. Courtney, Washington representative of the A. S. A., shows how the National Bureau of Standards has grown since it was established in 1901 by Congress. The Bureau now has two divisions: the first is the research and testing division which has nine technical sub-divisions—electricity, weights and measures, heat and power, optics, chemistry, mechanics and sound, organic and fibrous materials, metallurgy, and clay and silicate products; the second division has three sub-divisions—simplified practice, trade standards, and codes and specifications. There are 858 employees in the first division and 61 in the second.

Cooperation of the National Bureau of Standards with the A. S. A. is shown by the Bureau's official representation on over 100 A. S. A. committees and by sole or joint sponsorship by the Bureau for 18 A. S. A. projects. Methods of developing simplified practices, trade standards, codes and specifications are outlined, and the organization and work of the Federal Specifications Executive Committee are explained. All of the above work and groups are within the Department of Commerce.

(*Continued on page 28*)

IN ATLANTIC CITY— IT'S MATHIESON CHLORINE



Water Department
City Hall
Atlantic City, N. J.

May 6, 1939

The Mathieson Alkali Works, Inc.,
60 East 42nd St.,
New York, N. Y.

Gentlemen:

We are glad to reply to your inquiry concerning our use of your products.

We have been users of Mathieson Chlorine for about 20 years in which time we have received excellent service from your organization.

One feature we have particularly appreciated is the freedom from trouble with clogging tubes. At the time we experienced this difficulty when using another source of supply.

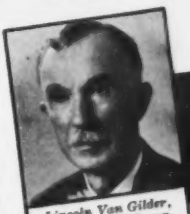
For the past five years we have found your multiple unit cars a great convenience as well as an economy. These cars eliminate extra handling of cylinders because of the greater capacity of the containers.

We are also users of HTH which is highly satisfactory for use in sterilizing our pumping basins, and in addition easy to use.

Yours very truly,

Engineer and Supt.

LVGIB



Lincoln Van Gilder, Engineer and Superintendent, Water Department, Atlantic City, New Jersey



Left, Maurice Brunstein, Chemist and Assistant Superintendent, and right, Frank J. Trumbore, Chief Plant Engineer, who were responsible for the location and design of the new Chlorine Treatment House and its unique facilities for handling ton containers.



The new Chlorine Treatment House, Atlantic City Water Department, showing ton containers of Mathieson Chlorine.

The Atlantic City Water Department, as stated by Mr. Van Gilder in the above letter, have been users of Mathieson Chlorine for over twenty years. Until about five years ago deliveries were taken in 105-lb. cylinders. Then it was decided to take advantage of the economy and convenience of Mathieson Chlorine in multiple-unit tank cars carrying fifteen one-ton containers. Atlantic City also uses Mathieson Ammonia for chloramine treatment and HTH for sterilizing pumping basins, etc.

Atlantic City is only one of many progressive cities throughout the country that find Mathieson Chlorine the ideal answer to the need for a pure chlorinating product—trouble-free containers and valves, prompt delivery service, and courteous, expert cooperation at all times, whether the job be water purification, sewage treatment or swimming pool sanitation.

Write today for a copy of our interesting and informative 80-page manual—"Hypo-Chlorination of Water."

THE MATHIESON ALKALI WORKS INC., 60 EAST 42ND STREET, NEW YORK N. Y.
LIQUID CHLORINE HTH AMMONIA, ANHYDROUS and AQUA BLEACHING POWDER SODA ASH CAUSTIC SODA
BICARBONATE OF SODA PH PLUS FUSED ALKALI DRY ICE LIQUID CARBON DIOXIDE

(*Continued from page 26*)

Described in the second article is the work on specifications by the War and Navy Departments. An index of U. S. Army and federal specifications is published annually by the War Department. The current index contains 3,700 items and it is expected that there will be 7,300 items when the standardization program is complete. Both the War and Navy Departments cooperate very closely with the National Bureau of Standards, the A. S. A. and other groups. Where no federal specification exists, the Navy draws up and uses its own.

Alleging publication of misleading representations which unfairly disparage aluminum cooking utensils, the Federal Trade Commission has issued a complaint against Scientific Manufacturing Company, Inc., and its president, Howard J. Force, of Scranton, Pa.

The pamphlets, designated "Poisons Formed by Aluminum Cooking Utensils" and "Are You Heading for the Last Round Up," are alleged to contain representations of which the following are typical: "A friend of mine after having 17 carbuncles, threw out his fancy aluminum ware. The carbuncles disappeared."—"Another fed his dog from an aluminum

(*Continued on page 30*)

DIFCO

Plate Media

for Confirmation of the Presumptive Test

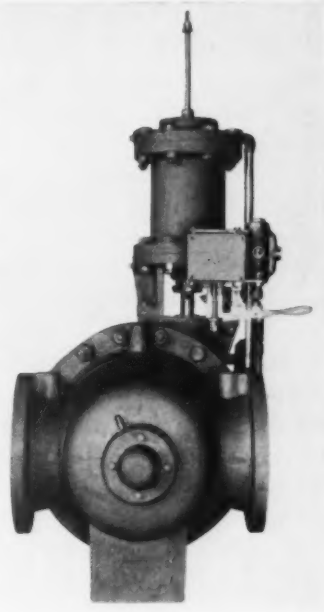
Levine's Eosin Methylene Blue Agar, Difco, is recommended for confirmation of the presumptive test for coliform bacteria in water. The formula of this medium conforms to that approved in "Standard Methods of Water Analysis" of the American Public Health Association. On plates of this medium colonies of *Escherichia coli* are dark and possess a metallic sheen while those of *Aerobacter aerogenes* are mucoid and wine colored.

Bacto-Endo's Agar is also widely used for confirmation of the presumptive test for coli. Colonies of *E. coli* are red with a metallic sheen and are surrounded by a red zone. The formula of this medium corresponds to Formula II of "Standard Methods."

Specify "DIFCO"
THE TRADE NAME OF THE PIONEERS
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They are the *Ideal* Valves where *Positive Control* is required and are suitable for use as:

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- LINE VALVES where quick and easy valve closure is essential

FOR FULL INFORMATION ADDRESS

RENSSELAER VALVE CO.

TROY, NEW YORK

(*Continued from page 28*)

dish; the dog died from cancer of the face."—"Two others each gave a dozen young ducks water in aluminum pans and all the ducks died in less than two weeks."—"Cancer has increased in Austria in proportion to the increased use of aluminum ware."

These, and similar representations, the Commission charges, deceive the public into the erroneous belief that aluminum utensils are a menace to the health of users, when in truth, they are not unsafe, poisonous, nor deleterious to man when properly used in the preparation or keeping of foods. And they are used extensively in hospitals.

Built-in individual automatic control of both day and nighttime temperatures, at low cost, is now provided in Grinnell Automatic "Thermolier" Unit Heaters, made by Grinnell Company, Inc., of Providence, R. I. The control can be added to existing unit heaters of any make, as it need only be tied into the line at the heater itself. Heart of the device is a bulb-type thermostat containing a solid liquid charge, mounted within the heater housing. Two pointers—one for day, one for night—are adjusted over a 60° range by someone in authority and locked. Thereafter,

(*Continued on page 32*)

ANNOUNCING!

NEW BULLETIN

Discusses the various types of Infilco aerators and their functions in (1) removing undesirable gases, (2) oxidizing or adding dissolved oxygen, and (3) removing odors.

Write today for your copy of Bulletin 100. There is no obligation, of course.



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Practical Application of the Langelier Method

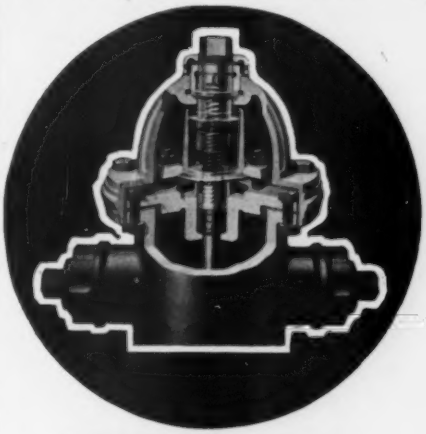
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These copies are flat, unbound, unaccompanied by text matter.



THIS HYDRANT OILS ITSELF

Even if you should forget to oil your MUELLER-COLUMBIAN Hydrant, it will oil itself for many years because of the dry top construction that contains the SELF-OILING Reservoir. Look what that means to you,

1. Insures easier turning of the operating nut since the threads and collar are always lubricated.
2. Prevents corrosion of parts, since they are constantly immersed in oil.
3. Eliminates excessive wear of parts because an oil film between surfaces prevents friction.
4. Oil is non-freezing to minus 60 degrees and since all parts are in an oil bath, no ice forms (from atmospheric condensation) to make moving parts in-operative.
5. Oil reservoir and packing gland being of one piece, oil seeps from reservoir on top of hydraulic packing, keeping it moist and prevents its drying out which would cause leakage.

MUELLER CO.
CHATTANOOGA, TENN.

(*Continued from page 30*)

day and night settings are made by a simple pull-cord control hanging from the heater. A special setting makes possible summer operation of the fan alone, under automatic thermostat control, without additional wiring or other changes.

Charges for private fire protection service have recently been at issue in the court of a middle western city. The circumstances are so unusual as to merit record here, although the city will not be named:

In the course of routine inspections about the city, an employee discovered that a certain factory was completely sprinklered, but could find no record of the installation. There are quite a few other sprinklered risks in the city for which a service charge is made and which is paid without discussion.

Investigation disclosed that the newly discovered installation had been in service since 1923. A bill was rendered for the entire period. The industry refused to pay and the matter went to court. During the trial two contentions were made by the industry. The first was that there had been a personal agreement made with the former water works superin-

(*Continued on page 34*)

DOUBLE-LID
METER BOX COVERS

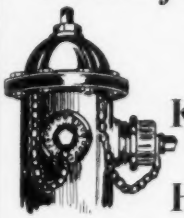


Ford double-lid meter box covers provide dead-air insulation in neck of cover and conserve heat in the meter box. Top lids are provided with the Ford Worm Lock. Write for catalog of meter box covers, double and single lid.

The Ford Meter Box Co.
WABASH, INDIANA

For over 50 years
O.K.'d
by the man
on the job



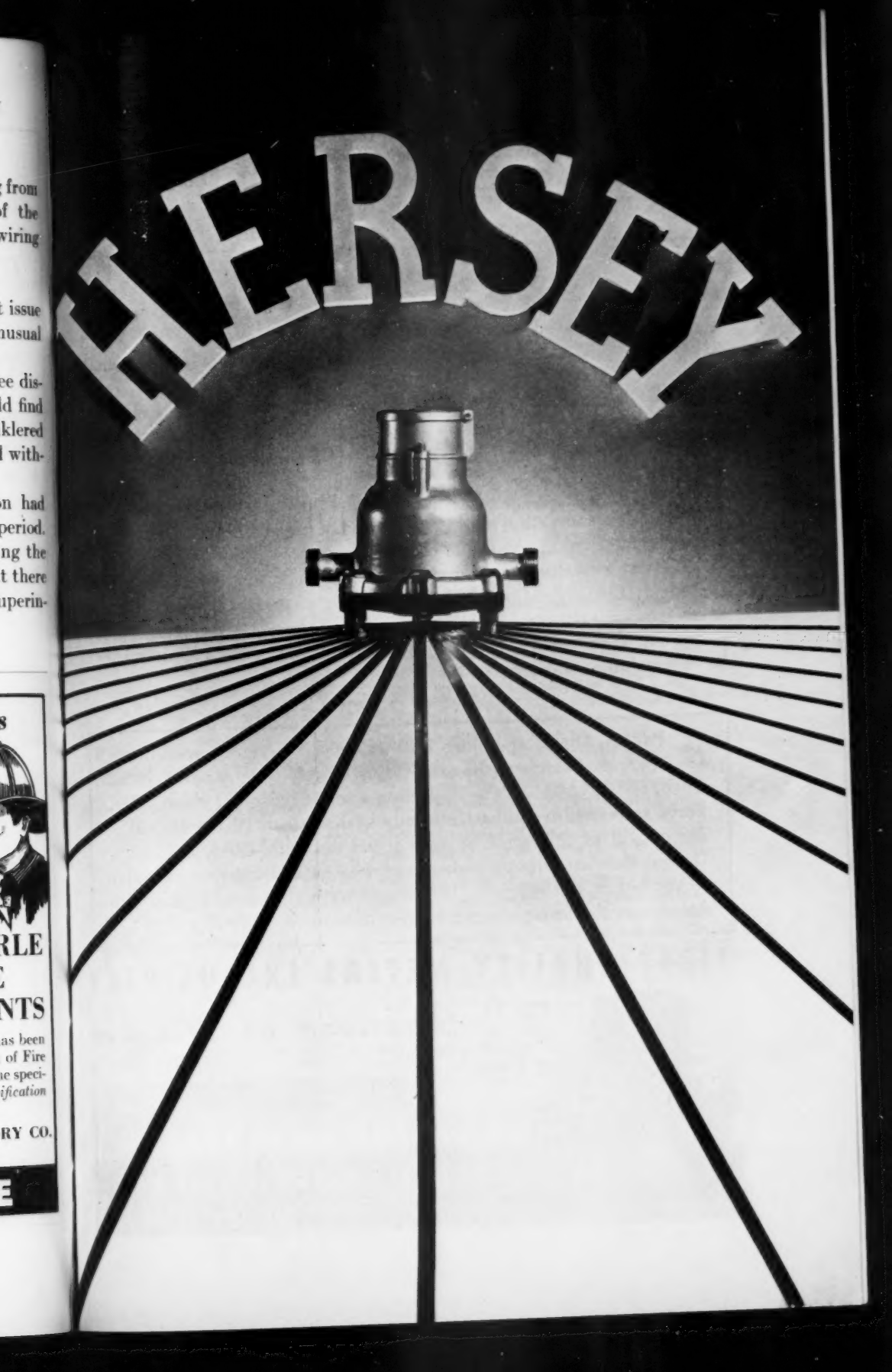


KUPFERLE
FIRE
HYDRANTS

Kupferle Fire Hydrant No. 100 has been tested and approved by the Board of Fire Underwriters and complies with the specification of the A.W.W.A. *Specification sheets sent on request.*

JOHN C. KUPFERLE FOUNDRY CO.
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HERSEY

COOK Well Strainers

A reciprocal relation, the life and functioning of the one depending much on the other.

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COOK Deep-Well Turbine Pumps

(*Continued from page 32*)

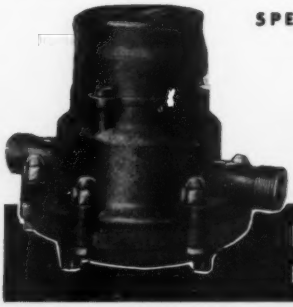
tendent that no charge would be made for the service. The court held that such confidential agreement, if ever made, was improper. The second defense was that the statute of limitations saved the industry against collection of the entire bill. The court also overruled this and referred to parallel decisions of great importance to water works men. It was held that the fire protection service rendered by the water department was a "continuous service" and that the service was still being rendered. The Supreme Court of the State in which this case was heard has held that when the service rendered by a claimant is continuous, the statute of limitations does not apply during the period of such continuous service nor within six years of the cessation of such service.

To water works men who may not be already advised of such legal precedent, the suggestion is made that the department's attorney be asked to review the law in that State. If the precedents are similar, many claims for water service of the mysterious, not-previously-billed type can be successfully collected.

(*Continued on page 36*)

Paul A. Diehl, who since 1925 has been western representative for Black & Veatch of Kansas City, Mo., died on August 19 at Altus, Okla., where he was inspecting a sewage disposal plant. Mr. Diehl graduated from the University of Kansas in 1919 with a B.S. degree and at that time became associated with Black & Veatch. He was for some time resident engineer on construction of water works, sewer systems, etc., before making his headquarters at Los Angeles as the firm's western representative.

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If improvement is desirable in your own community's water service, it will cost not a whit to have a skilled Pittsburgh-Des Moines Engineer make a preliminary survey of the problem. His broad experience has been gained in dealing with similar needs in like communities—and he will be glad to detail to you and other interested local authorities how P·DM Elevated Water Storage assures continuous water supply at uniform pressures throughout the day and year . . . how it lowers operating costs, and *betters* service for every consumer.

Let us arrange a consultation for you—and meanwhile, send you our informative 20-page bulletin on "Modern Water Storage in Elevated Steel Tanks." No obligation, of course!

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Dallas, 1229 Praetorian Building . . . San Francisco, 631 Rialto Building

(*Continued from page 34*)

Savings in shop and field time on welded pipe installations are said to be effected by use of the Trumark protractor, recently put on the market by Advance Sales Company of Los Angeles. This marking device is designed to give immediate and accurate cut lines and layouts on any size of pipe, for torch cutting, sawing or shearing, without the use of templates, wrap-arounds or engineering computation.

The protractor is placed on the pipe or any rectangular shape and is held in level position by a strong spring chain. The level is determined by a bubble indicator. Any desired angle for the cut is set on the 180-degree scale. The marking arm may then be moved completely around the pipe. The marking is done by a special chalk that will not blow off. The protractor is constructed of cast aluminum alloy, is rigid in marking position and scribes a true line. Four models handle pipe up to 3-, 6-, 12- and 36-inch, respectively.

The A. S. T. M. at its recent convention put forward for final approval quite a series of specifications. The complete record of these activities appears in the "Summary of Proceedings of the 42nd Annual Meeting."

(*Continued on page 38*)



STRONG - TIGHT AND FLEXIBLE!

Regardless of where you lay cast iron water mains —under paved streets, railroads or over bridges— you can depend on HYDRO-TITE to make joints that are not only strong, tight and flexible but "lasting". HYDRO-TITE is easy to prepare and use. It has a record of over 25 years without a single failure anywhere.

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A DEPENDABLE SELF - CAULKING JOINT COMPOUND

American Water Works Association
60th Annual Convention
Kansas City, Mo., April 21-25, 1940

Scheduled Hotel Rates

Rooms	Phillips	President	Muehlebach
Single Bedroom	$2.50- 5.00	$2.50- 5.00	$3.50- 6.00
Double Bedroom, 2 persons	4.00- 8.00	4.00- 6.50	5.00- 8.00
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Parlor and 1 Bedroom	12.00-15.00	15.00	15.00-25.00
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Special Castings ***Short Body B. & S. Specials***

Warren (WF) Spun Centrifugally Cast Iron Pipe

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments

(*Continued from page 36*)

Items of interest in the water works field are a group of standards for paint materials, another group on soaps and detergents, and a larger group on ferrous metal products.

Trustees of the Florida Section of the American Water Works Association met with officials of the University of Florida August 21 to settle details of the annual Short Course in Water and Sewage Treatment. It was decided to hold the course at the University of Florida October 18–21 under the joint sponsorship of the General Extension Division of the University of Florida, the Florida Section of the American Water Works Association and the Florida State Board of Health.

Dr. A. P. Black, of the University and Secretary of the Florida Section, estimated approximately 150 engineers and water and sewage plant operators will attend the four-day period of intensive study.

The program will include discussions on chlorination, water softening and purification, water pumps, elevation of tanks and cutting in new mains, sewage and garbage disposal, record keeping, and other subjects in which Florida plant operators desire instruction.

(*Continued on page 40*)

CLEAN YOUR WATER MAINS

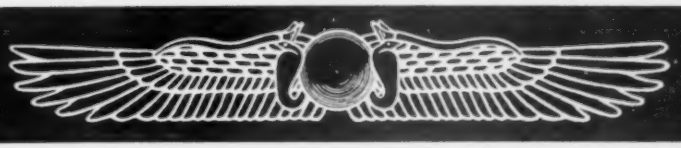
One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

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Accurate Measurements of Low Turbidity
Manufactured by
THE FERGUSON COMPANY
Manufacturers of Scientific Apparatus
for Water Works Laboratories
Glass Blowing to Sketch
1643 Warner St., Baltimore, Md.
Write for Literature

Help Build up Your Association by Bringing in a New Member
Application Blank On Request
AMERICAN WATER WORKS ASSOCIATION
22 East 40th St. NEW YORK CITY

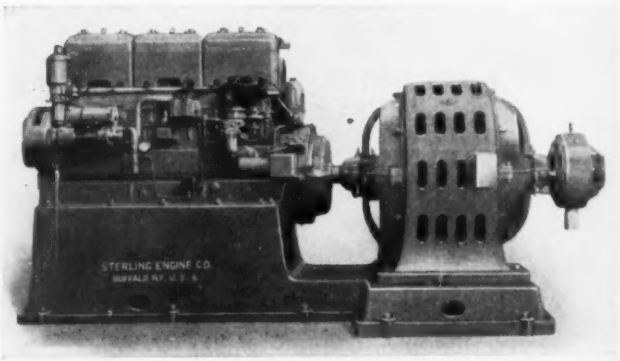
(*Continued from page 38*)

A committee composed of Dr. A. P. Black, University of Florida, chairman; L. D. St. John, Jacksonville; R. E. Gibson, Fort Myers; Frank Kelley, Belle Glade; and, Graham McKeown, Quincy, was appointed by George F. Catlett, Chairman of the Florida Section and Sanitary Engineer for the State Board of Health, to put the program in final form and to secure authorities to handle the chosen subjects. The committee was advised to develop the program on a practical basis, and to select instructors who will adapt their subjects to Florida's existing problems.

(*Continued on page 41*)

THE STANDARD OF EXCELLENCE IS UPHELD BY INFORMED ENGINEERS!

Sterling High Duty Internal Combustion Engines



Guntersville Dam, T. V. A. emergency generator set, (Electric Machinery and Manufacturing Company Generator), driven by a Sterling Viking 6-cylinder engine rated 425 H.P. 1200 R.P.M. Engine officially government tested 12 hours, loaded 306 K.V.A. at unity power factor; produced far in excess its rated horsepower without employing the correction factor.

A Standard, set up in specifications, secures better built products. The Sterling Viking Engines are full load stationary engines. Witness the performance! Engines consist of more than rated horsepower and price.

Engineers secure for their clients and for their government properly designed and built equipment by specifying it.

STERLING ENGINE COMPANY

Home Office and Plant 1270 Niagara Street Buffalo, N. Y. Dept. C-3 Branch Office 900 Chrysler Bldg. New York, N. Y.

OUR ZEOLITES—BASEX AND HI-BASEX

Perfection in highly refined, durable, efficient greensand zeolites for open gravity or closed pressure water softeners.

Extensively used with entire satisfaction for over 15 years

Send for Details

HUNGERFORD & TERRY, Inc., Clayton, New Jersey

also manufacturers of the well known INVERSAND water softener

(*Continued from page 40*)

According to B. C. Riley, Dean of the General Extension Division, tests will be given those who attend the course. While no tests will be compulsory, the grades will be the basis for issuing certificates of merit to enrollees.

A fee of $2.00 will be charged each person who enrolls. This fee will entitle the enrollee to a free copy of a book entitled "Waterworks for the Practical Man" and outlines of lectures in note-book form.

A banquet will be held for those who attend the short course on Friday evening October 20, while other forms of entertainment will be arranged throughout the duration of the course by University officials.

(*Continued on page 42*)

Carl Lager, President of Morris Machine Works, Baldwinsville, N. Y., died July 17. Mr. Lager was born in Sweden in 1869 and came to this country in 1887 after graduating from a technical school and having some shop experience in Sweden. He became a draftsman and foreman for the Allsing Company in Brooklyn and also worked for Henry R. Worthington in Brooklyn. However, most of his life's work was with the Morris Machine Works, where he spent nearly fifty years. He designed pumping machinery for water works, sewage plants, drainage systems, dry docks, mines and dredges.

M. H. Morris has been appointed President to succeed Mr. Lager; J. L. Lonergan who has been with the Company for 37 years, has been made Vice-President and General Manager. A. G. Forssell, who has been Chief Engineer and Sales Manager for the past 5 years, is now Second Vice-President, and R. S. Mercer is Secretary and Treasurer.

(*Continued from page 41*)

Fifty-seven courses in engineering will be given in the Extension Division of Columbia University during the 1939–1940 academic year, which begins on September 28, it is announced by Dean Joseph W. Barker of the School of Engineering.

Classes have been scheduled in the late afternoon and evening, and on Saturday mornings in order that practicing engineers in the metropolitan district may enroll. Among the new courses which have been introduced into the curriculum are a series of lectures on sound engineering by Dr. Harry F. Olson, director of acoustical research for the Radio Corporation of America, and eighteen lectures by engineering consultants on the economic, aesthetic and structural design of bridges.

Seven courses have been designed particularly for engineers who are engaged in industrial activities. Advanced structural analysis and design will be taught by Professor J. M. Garrelts, and elements of electrical engineering and direct current machinery by Professor F. W. Hehre. Three other courses in electrical engineering are included in this group: "Elements of Alternating Currents and Alternating Current Machinery," by Professor J. A. Balmford; "Theory and Operation of Alternating

(*Continued on page 44*)

ADVERTISING RATES

Journal of the

AMERICAN WATER WORKS ASSOCIATION

22 EAST 40th STREET NEW YORK, N. Y.

1. **GENERAL ADVERTISING**

(a)

	1 Month (per issue)	3 Months (per issue)	6 Months (per issue)	12 Months (per issue)
1 page	$80.00	$65.00	$55.00	$50.00
1/2 page	50.00	40.00	35.00	31.00
1/4 page	35.00	25.00	20.00	18.00
1/8 page	18.00	14.00	11.00	9.00

1/12 page—Professional Card (under special classification only) $3.00

(b, c) No time or space discounts.

(d) Covers and special positions—Yearly basis.
Outside front—no advertising.
Inside back $60.00
Other special positions 60.00
Inside front 65.00
Outside back 90.00

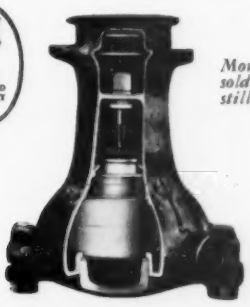
(e) Minimum size of advertisement is 1/8 page—2 1/8" long by 1 3/4" deep (except Professional Card—1/12 page under special classification).

(f) Space to be used within one year from date of contract.
Color and insert rates on application.

2. **CLASSIFICATIONS**—(a, b)—None. (c, d)—Professional Card—1/12 page. Limited to advertisement of professional services. Further information upon request.

THE TRIDENT METER

is not a static mechanism. The disc principle is basic, and remains unchanged, as does also the principle of interchangeability. But through the years, the meter itself has been constantly subject to refinements . . . and these refinements can be incorporated, through interchangeable parts, in Tridents that have seen 20—30 or even 40 years of service, making them actually better than when they were new, eliminating obsolescence, protecting capital investment, minimizing maintenance.



More than 5½ million sold—the great majority still in service.

MODERN INTERCHANGEABLE PARTS IN AN 1899 TRIDENT WATER METER

Neptune Meter Company, 50 West 50th Street (Rockefeller Center), New York City. Branch Offices in Principal Cities. Neptune Meters, Ltd., 345 Sorauren Avenue, Toronto, Canada

Trade Mark MABBS Reg. U. S. Pat. Off.

PREVENT WEAR AND CUTTING of rods, plungers and shafts by using

MABBS RAWHIDE PACKING

on your Water Works and Sewage pumps and valves. Practically antifrictional, it saves enough in POWER to pay for itself in a short time. For over 45 years Mabbs Rawhide Packing has proven its superiority over other packings for these purposes.

Why not use it in your plant and benefit thereby?

MABBS HYDRAULIC PACKING COMPANY, *Inc. 1892*, 431 S. Dearborn St., Chicago, Ill.

(*Continued from page 42*)

Current Machinery," by Professor G. T. Harness; "Illumination of Buildings," lectures by six specialists in the field under the direction of A. L. Powell.

"Operation and Management of Public Utilities" will be the subject of a course by Professor R. T. Livingston, to be included in those planned for active engineers. Another such course, "Acoustics of Buildings," will be directed by Vesper A. Schlenker.

Foundation engineering, a comparatively new branch, will be the theme of a series of lectures on advanced and experimental soil mechanics by Professor D. M. Burmister. Comprehensive consideration of the physical character of the soil and development of the basic notions of soil behavior will be part of the advanced course, while individual investigations and laboratory technique will comprise the experimental work.

The Department of Mechanical Engineering will offer work in fluid dynamics, lubrication, and power analysis. "Nomographic Charts and Empirical Equations," will be taught in a special mathematics course arranged for engineering students with Professor Burmister in charge. Studies in engineering and architectural drafting will also be conducted.

WATER-BORNE OUTBREAKS
***in* THE UNITED STATES *and* CANADA**
1920—1936

by

Arthur E. Gorman and Abel Wolman

An unparalleled summary of studies concerning the relation of water supplies to typhoid fever, gastro-enteritis, etc.

A brochure that should be in the library of every sanitary engineer.

Price $1.25—postpaid if cash or check accompanies the order.

Sold only by

THE AMERICAN WATER WORKS ASSOCIATION
22 East 40th St., New York, N. Y.

APPLICATION FOR MEMBERSHIP
IN THE
AMERICAN WATER WORKS ASSOCIATION
22 East 40th Street, New York, N. Y.

Date:.....

....hereby make application for
(I or We)

.....
(Active, Junior, Corporate or Associate Membership, or Affiliate)

in the American Water Works Association, and enclose herewith the sum of $....., one year's dues in advance.

Name .....

Company or Department.....

Title or Position.....

Address.....

.....

If application is for Junior Membership, give date of birth.....

If application is for Affiliate, state number of active services in property where employed .....

Nature of business or character of work (for office records).....

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If application is for Corporate or Associate Membership, it must be signed by the person designated to represent the firm or corporation in A.W.W.A. activities.

.....
Signature of Applicant

(over)

ARTICLE I OF BY-LAWS

Section 3. An Active Member shall be a superintendent, a manager, an official or employee of a municipal or private water works; a civil, mechanical hydraulic, or sanitary engineer, a chemist, a bacteriologist, or any qualified person engaged or interested in the advancement of knowledge relating to water supplies. (Annual Dues, $10.00.)

Section 4. A Corporate Member shall be a Water Board, Water Commission, Water Department, Water Company or Corporation, National, State or District Board of Health, or other body, corporation or organization engaged or interested in water supply work, and shall be entitled to one representative whose name shall appear on the roll of members, and who shall have all the rights and privileges of an Active Member. This representative may be changed at the convenience and pleasure of the Corporate Member on written notice to the Secretary. (Annual Dues, $15.00.)

Section 5. An Associate Member shall be either a person, firm or corporation engaged in manufacturing or furnishing supplies for the operation, construction, or maintenance of water works. (Annual Dues, $25.00.)

Section 6. A Junior Member shall be an employee of a municipal or private water works; a civil, mechanical, hydraulic, or sanitary engineer, a chemist, a bacteriologist, a student or any otherwise qualified person engaged or interested in the advancement of knowledge relating to water supplies. At the time of his admission he shall be not less than eighteen years of age. His connection with the Association shall cease when he becomes twenty-five years of age, unless he is regularly enrolled as a student in a university or has previously transferred to the grade of Active Member. Junior Members shall receive the Journal and all privileges of Active membership except holding office and voting. (Annual Dues, $5.00.)

Section 7. An affiliate shall be any person otherwise qualified for Active membership who, at the time of application, is not nor previously has been a member of the Association and who, for acceptable reasons, does not wish to become an Active Member.

No corporation, firm or partnership which otherwise would be entitled to the grades of Associate or Corporate member may hold the grade of Affiliate. No employee of an Associate member may become an Affiliate. No person who is the superintendent, the manager, the chief engineer, the superintendent of filtration, the chief chemist, or the superintendent of distribution in a plant having more than 3,000 active services, is eligible for the grade of Affiliate. Under unusual conditions, exception to the above may be made by action of the Executive Committee if the applicant sets forth fully the reasons for the exception when applying for the Affiliate grade.

Affiliates shall not be entitled to vote upon general Association questions, and not eligible to hold office in the Association, nor in any of its Divisions. They shall be eligible to vote upon Section questions and to hold Section offices except those of Chairman, Vice-Chairman, Secretary (and/or Treasurer). They shall be entitled to all other rights and privileges of Active Members. Affiliates receive the March, June, September and December issues of the Journal each year. (Annual Dues, $4.00.)

Memberships will be dated as of the beginning of the quarter in which the application is received.

Membership in the Association carries, also with no additional dues, membership in its Local Sections and National Divisions, and includes the Journal, a monthly publication devoted to water works interest. The proceedings of the annual conventions and of the meetings of the Local Sections are published in the Journal, which also contains contributed articles on subjects pertaining to public water supplies.

NEWS OF THE FIELD

The list of great figures of the water works profession in America will surely include, along with Sedgwick, Fuller, Mulholland, O'Shaugnessy and others, the name of Thaddeus Merriman. His labors helped to bring safety to millions in the New York and Los Angeles metropolitan areas through recent additions to their regional water supplies.

Thaddeus Merriman, Consulting Engineer and former Chief Engineer of the Board of Water Supply of New York, died at the age of 63 in New York City, Sept. 26. He was born in New Haven, Conn., a son of Professor Mansfield Merriman with whom he collaborated in the preparation of Merriman's Handbook for civil engineers. He graduated from Lehigh University as a civil engineer in 1897 and went to Nicaragua in the fall of that year to serve as chief of a party on survey for the Nicaragua Canal Commission. From 1899 to 1901 he was engaged on surveying, designing and constructing the Little Falls, N. J., filtration plant of the East Jersey Water Company and was also inspector in this country of materials for the Guayaquil & Quito Railway of Ecuador. From 1902 to 1905 he was division engineer on the construction of the Boonton, N. J., concrete masonry dam.

In 1905 he joined the New York City Board of Water Supply as Assistant Engineer on the general planning and estimating for the proposed Catskill supply. He was successively Assistant Engineer, Department Engineer, Deputy Chief Engineer, and in 1922 succeeded J. Waldo Smith as Chief Engineer. During his long career he directed or aided greatly the development of both the Delaware and Catskill supplies. Since 1933 he was engaged as a Consulting Engineer. He became an authority on cement and his reports and treatises on the subject were considered important contributions to the advances in the construction of large power and irrigation dams in recent years.

Mr. Merriman at one time was chairman of the engineering board of review of the Metropolitan Water District of Southern California; he was consultant to the War Department on the Fort Peck project in Montana and on flood control plans in Los Angeles and Orange Counties, California. He was also consultant to the Tennessee Valley Authority on the Norris and other large dams and was a Consulting Engineer on New York City's 540,000,000-gallon Delaware water supply system which is now under construction.

Mr. Merriman had been a member of the A.W.W.A. since 1920. He was active in the American Society of Civil Engineers, having served as a director in 1924 and 1926. He was also a member of the American Association for the Advancement of Science, the American Society for Testing

(Continued on page 2)

(*Continued from page 1*)

Materials, American Concrete Institute, Franklin Institute, Merchant's Association of New York, Century Association, Arkwright and Engineers Clubs.

Howard K. Bell, Consulting Engineer of Lexington, Ky., died at the age of 62, September 1 after an emergency operation for appendicitis. Mr. Bell graduated from Georgetown College in 1893 and from the University of Kentucky Engineering College in 1904. He was Chief Engineer and Manager of the Lexington, Ky., Water Works from 1906 to 1910, a general contractor from 1910 to 1913 and a designer and builder of water plants and a consulting engineer for the last 25 years. Mr. Bell was Chairman of the Kentucky-Tennessee Section in 1931–32.

Grant S. Bell, son of the late Mr. Bell, and James K. Latham will continue Mr. Bell's practice under the same name.

How Municipal Fire Defenses Affect Insurance Rates is the title of a most competently edited book just issued. It includes a discussion of the fundamentals of fire insurance and tells how a city is classified for insurance purposes, how the National Board of Fire Underwriters functions in this matter, how insurance rates and fire losses are related and how insurance rates can be reduced. There is also included a list of key questions for municipal officials to consider, the complete standard schedule of the N.B.F.U. for grading cities and a summary of the present insurance gradings of the 310 cities in the U. S. with a population over 30,000.

Since water supply is a key factor in fire protection and insurance rates, water works administrators will find this a valuable book. It is published by the International City Managers Association, 1313 East 60th St., Chicago. The price is $1.50.

Joseph Metzendorf has been appointed Sales Engineer, Ozone Processes, Incorporated, Philadelphia, Pa., effective September 25, according to an announcement by Morse DellPlain, President. Mr. Metzendorf, a graduate of Colorado State and New York Universities in mechanical engineering, was formerly with the Commonwealth Gas Corporation, New York, and one of the organizers of the Atlantic States Gas Company, a subsidiary in the Butane-Propane gas industry, and in which he acted in a sales and executive capacity. He was also formerly an engineering consultant to the Sierra Nevada Mining Corporation, California.

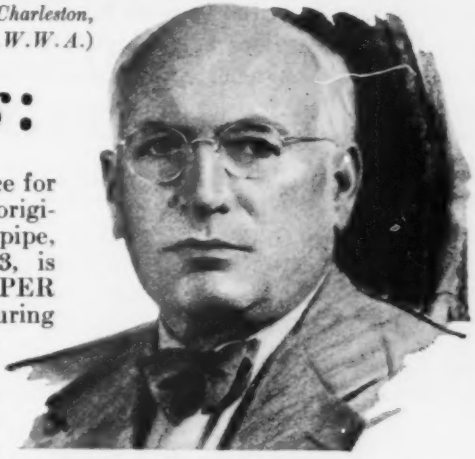
Ozone Processes, Incorporated, an operating company of the Welsbach Street Illuminating Company group, designs, manufactures, and installs equipment for the ozone processing of water and for other industrial uses necessitating large capacities of ozone.

(*Continued on page 4*)

J.E.GIBSON

(Manager, Water Dept., Charleston, S. C.—former President of A.W.W.A.)

writes:



"The cost of maintenance for the last five years on an original 24" line of cast iron pipe, 51,700 feet laid in 1903, is $28.01, or roughly 60¢ PER MILE PER YEAR. During the entire 36 years there has been only one break. All other repairs have been due to leaking joints caused by vibration or settlement. We think this is a splendid record."

Yours sincerely,

J. E. Gibson

Manager & Engineer.

Water mains represent about one-third of this country's 5-billion-dollar investment in public water-supply systems. More than 98% of these mains are cast iron pipe with a *known* useful life at least double the *estimated* life of other water main materials. Because the tax-saving, through deferred replacements alone, is enormous, cast iron pipe is known as Public Tax Saver No. 1.

CAST Q IRON

Look for the "Q-Check" Registered trade mark.
Cast iron pipe is made in diameters from 1¼ to 84 inches.
The Cast Iron Pipe Research Association, Thos. F. Wolfe, Research Engineer, 1015 Peoples Gas Building, Chicago, Illinois

CAST IRON PIPE
PUBLIC TAX SAVER NO. 1

(*Continued from page 2*)

The Allegheny and Monongahela Rivers appear slated for the blacklist as sources for water supply for Pittsburgh according to plans now being developed by Mayor Scully of that city. The mayor secured special legislative authority from the General Assembly two years ago to permit the city to build water lines outside of its own environs, to create a public corporation (not yet done), and to issue non-debt revenue bonds and sell water. None of the legislation passed by the Assembly has been tested in the courts. The first move by Mayor Scully is expected to be introduction in the city council meeting of legislation that would direct the city to condemn property outside of its limits, this being a preliminary means of testing the specially granted powers.

Chief points expected to be tested in courts are: whether the city can sell water for profit; whether the city can go outside its limits to condemn property for any use; and whether any corporation, without assets or credit, can issue any kind of bonds. Plans for the new water supply project are reported to entail an expenditure of $70,000,000 to $80,000,000.

Work of the Red Cross is exemplified by its course of action when the

(*Continued on page 6*)

For Underground Service Lines

ANACONDA COPPER and RED-BRASS



Anaconda Copper Tubes in straight lengths and coils... Anaconda "85" Red-Brass in straight lengths only – both are products of dependable quality. Made by the world's largest and most experienced manufacturer of copper and brass, and stocked by leading supply houses.

3924

THE AMERICAN BRASS CO.

General Offices: Waterbury, Connecticut

Save TIME *and* TROUBLE *with this* QUICKER HEALING Pipe Jointing Compound

INITIAL leakage heals quickly. Trenches need not stay open for days. Traffic hazards and inconvenience are quickly ended . . . all this when you joint your bell and spigot lines with Tegul-MINERALEAD • Joints are easily made and permanently tight. No skilled labor, caulking or deep bell holes needed • Tegul-MINERALEAD comes in 10 lb ingots, easy to handle, ship and store • No possibility of composition changing under jolting in transit • No fear of rain, snow or flood, if stored in the open • For more information, write

A Tegul PRODUCT

Tegul-

The ATLAS MINERAL Products Company of Pa. Mertztown, Pennsylvania

MINERALEAD

"One part in a Million"—

Threshold Treatment with Calgon prevents scale and stops after-precipitation in municipal water systems . . .



CALCIUM CARBONATE encrusted sand taken from a water supply filter bed. Threshold Treatment with Calgon prevents the after-precipitation of calcium carbonate typified by the above rock-like formation.

HERE'S a fact so amazing that, as research engineers, we hesitated to believe it ourselves—but its truth has been definitely established both in the laboratory and actual practice. Only .5 to 2 parts of Calgon (sodium hexametaphosphate) per million parts of water positively stops the encrustation of filters and the formation of scale in all parts of distribution systems.

No longer is it necessary for any municipal water supply to cause trouble due to scale because the cost of Threshold Treatment is always low. Its benefits carry over from your system right into the homes and plants of every user, where it minimizes deposition in hot water heaters.

The advantages of Threshold Treatment with Calgon are so great and its application so simple that it deserves serious attention from all water supply executives. We will gladly send more information or a service engineer. Just mail the coupon.

CALGON, INC.

SUBSIDIARY OF HAGAN CORPORATION

Chemical and Combustion Engineers

Calgon, Inc., 300 Ross St., Pittsburgh, Pa.

Please send information on Threshold Treatment. I am interested in ☐ scale prevention ☐ corrosion control.

Name_____

Company_____

Address_____

City_____ State_____

(*Continued from page 4*)

Ohio and Mississippi rivers went on a rampage in 1937. The American Red Cross had a total of more than 1,000,000 persons to care for up and down the rivers. Provision of safe drinking water was a problem, but it was solved, at first by transporting water, known to be safe, to the camps, and subsequently by piping tested water to refugee centers. The medical service of the Red Cross has set down exceedingly strict rules in this regard due to the great hazards involved in times of disasters covering large areas and involving great numbers of people.

Last New Year's, when the city of Toledo was threatened with a sudden water shortage, the Red Cross made arrangements with various railroads and neighboring cities to run in a supply of water in tank cars.

Assistance in time of need is the watchword of the Red Cross. To enable maintenance of its many services and also prepare it for any eventuality due to the unsettled state of affairs throughout the world, it is planned to enlist 1,000,000 new members this year. The annual Roll Call, when everyone will be invited to join a local chapter and thus help support Red Cross activities, begins Armistice Day and ends Thanksgiving.

(*Continued on page 8*)

EDSON
DIAPHRAGM PUMPS

Hand Operated—size 2″, 2½″, 3″, 4″
Power Operated—size 3″ and 4″
Open Discharge or Force Pump
Skid, Truck or Trailer Mounted

Complete Pump Outfits, Genuine Edson Pumps, Suction Hose, Brass Couplings, Bronze Clamps, Red Seal Diaphragms, Brass Strainer or Foot Valve, Hose Spanners, Adapters, Etc. Brass Hydrant Pump.

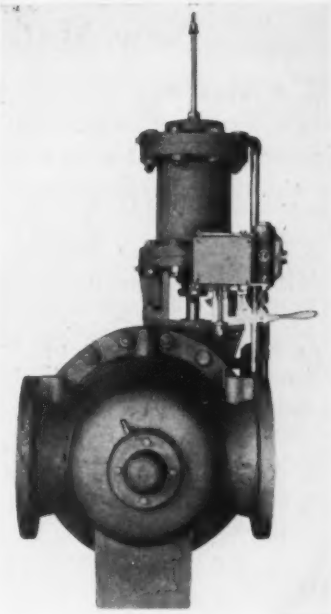
THE EDSON CORPORATION
Main Office and Works: 49 D St., South Boston, Mass.
New York: 142 Ashland Pl., Brooklyn

WHITE
FILTER SAND
98% Pure Silica

Washed, Screened and Dried. No Freight on Moisture—Prompt shipment in Bags or paper lined Box Cars—Write or wire us for information and prices.

DAWES SILICA MINING COMPANY
Silica Mines
THOMASVILLE, GEORGIA

RENSSELAER ENTERS THE CONE-VALVE FIELD



Rensselaer Cone-Valves are equipped with a Patented HYDRAULIC OPERATING DEVICE, which is Simple, Positive, and Efficient

They are the *Ideal* Valves where *Positive Control* is required and are suitable for use as:

- **ALTITUDE CONTROL VALVES**
- **PRESSURE CONTROL VALVES**
- **AUTOMATIC CHECK VALVES**
- **PRESSURE RELIEF VALVES**
- **FREE DISCHARGE VALVES**
- **LINE VALVES** where quick and easy valve closure is essential

FOR FULL INFORMATION ADDRESS

RENSSELAER VALVE CO.

TROY, NEW YORK

(*Continued from page 6*)

New Materials and Gadgets

1. A rate of flow indicator of the differential pressure type with pressure ranges between 0–30 in. and 0–225 in. of water has been put on the market. No mercury is used in the indicator, the differential pressure being balanced by a calibrated bellows unit.

2. A new rubber dressing for automobile tires, rubber mats, etc., is reported to clean and cover rubber with a sleek, black coat in one operation.

3. A new material to lift or loosen paint, varnish, shellac, lacquer, etc., is now made without benzol, acid or alkali. The compound is said not to drip or run when applied to ceilings or vertical surfaces.

4. A portable all-metal fire escape is now on the market. It is similar to a chain ladder except that the rungs are made like wide stirrups to help prevent slipping. A fire escape for a 3-story building weighs 20 lb. and has a load capacity of 1,800 lb.

5. A wheel conveyor that can be moved and reassembled by one man is now available. The conveyor has a capacity of 700 lb. and ball bearings that are not to be oiled. Each 10-foot section weighs only 66 lb.

6. A clear desk top for typists is now possible through the use of a new copy holder that is mounted on lazy tongs swung from the side of the desk.

7. Strip flooring finished at the factory is now on the market. It is hardwood, tongue-and-grooved, beveled on ends and edges, sanded, finished and waxed.

8. To carry ladders or scaffolding, a trailer has been designed that can be moved by one man or can be towed by an automobile. It supports scaffolding up to 40 ft. high or a ladder with a work platform up to 50 ft. high.

9. A two-alarm fire alarm has been developed so that a small fire in a room sounds a factory alarm and a large fire sounds an alarm in the city fire station. The installation is one of hollow tubing on the ceiling of each room. Heat expands the air in the tubing to sound alarms.

Readers can obtain further information by sending a postal to the A. W. W. A. headquarters giving the reference numbers of any of the above items and citing the October issue as the source.

(*Continued on page 11*)

(*Continued from page 8*)

Chlor-o-heater is the name of a heater developed by Proportioneers, Inc., Providence, R. I. The heater is designed to draw a maximum current output of 700 watts and to heat an enclosure of 700 cu.ft. to 40°F. at an outside temperature of 2° below zero.

Pierce J. McAuliffe, formerly with the Morris Machine Works at Baldwinsville, N. Y., is now representative for that firm with offices at 254 West 31st St., New York City. Mr. McAuliffe joined the Morris Machine Works in 1910 as a designer of hydraulic dredging equipment. During the War he was with the Construction Division of the Emergency Fleet Corporation, becoming manager of ship construction in 1918. He rejoined the Morris Machine Works in 1920.

Alfred E. Skinner, Western Manager of the Pitometer Co., Chicago, has retired and moved to southern California. He has been a member of the A.W.W.A. since 1921 and for several years was Secretary of the Illinois Section. He was associated with the Pitometer Co. since 1917. C. R. Bird, District Manager for the company at Detroit, is taking over Mr. Skinner's work.

(*Continued on page 12*)

ANY OLD JOURNALS FOR SALE?

Do you have back issues of the Journal which you will make available to the Association to help replenish its stock? Send a post card telling which you have of the numbers listed below and 50¢ will be paid for each copy obtained.

1922—March
1924—January, May, July, September
1926—January, May, June, September, November
1929—January
1936—April
1937—January, February, March
1938—January

American Water Works Association
22 East 40th St., New York



(*Continued from page 11*)

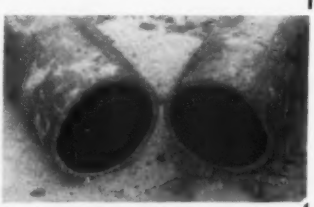
Far be it from this Journal to add to the quandary in which the football schedulers and calendar printers find themselves over the correct date for Thanksgiving. But the national "turkey" day has an added cloud over its success as the result of a recent study recorded by the Journal of the American Veterinary Medicine Association. It now appears that the well known bird is often the victim of paratyphoid and may have some relation to sporadic outbreaks of that disorder among humans. While the well roasted bird on the dinner table is an unlikely carrier, it does appear that safety indicates the wisdom of very adequate roasting.

Russel G. Creviston has been appointed to the new position of director of trade relations with Crane Co. H. H. Simmons, advertising manager, has been promoted to manager of advertising and sales promotion, succeeding Mr. Creviston who held that position for the past ten years.

William Mulholland, Father of the Los Angeles Municipal Water System, who died in 1935, will have dedicated to his memory an illuminated fountain memorial in Los Angeles.

(*Continued on page 14*)

2,000,000 FEET OF
Mono-Cast Enameline Pipe Now Serving Satisfactorily



Mono-Cast Enameline Pipe cut in the field, using ordinary hammer and cleaver.

SINCE first being offered to the trade in April, 1938, more than 2,000,000 feet of Mono-cast Enamaline Pipe have been installed with outstanding success in water transmission and distribution lines. Write for detailed literature on this Mono-Cast Centrifugal Pipe lined by a new and improved centrifugal process which reduces friction losses, assures permanent high "C" values and materially lowers pumping costs.

American Cast Iron Pipe Co.
BIRMINGHAM, ALA.
New York City Chicago Kansas City Minneapolis Dallas
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RUSTOP *the*
Cathodic Method of Eliminating and Preventing Rust and Corrosion in Steel Water Tanks.
Eliminates the Necessity of Painting below the Overflow.
Now Used by Many Cities And Manufacturers. Write For List Today.
Cleans Old Tanks. Keeps New Tanks Clean.
(Pat. Pend.)
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Efficient operation of filtration and water treatment plants depends upon the proper control of variable conditions. Such conditions must be accurately known to be properly controlled.

Foxboro Centralized Control brings to one central and convenient station supervision of the entire plant. It enables the operator to tell, at a glance, the levels in the various wells and reservoirs, wherever located, what filters are in operation, what equipment is shut down. And more important, it gives him, at his finger tips, precise and dependable control of all valves, pumps, or other equipment wherever it may be and whatever its function.

Foxboro Centralized Control, as an integral part of plant design, makes possible appreciable savings in construction and piping layouts. Foxboro engineers will gladly consult with architects, engineers and plant superintendents on any phase of plant instrumentation. Correspondence is invited. Ask for our new Water Works Bulletin 233.

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The FOXBORO COMPANY
150 Neponset Ave., Foxboro, Mass., U. S. A.

Branch Offices in 25 Principal Cities

(*Continued from page 12*)

Mulholland was born in Belfast, Ireland, in 1855, where he attended school until he was 15. At that age he started out to see the world as a seaman. After several years at sea, he worked on the Great Lakes and in the lumber camps of Michigan. In 1876 he went to Pittsburgh to live with his uncle who owned a dry goods store. At that time he read Nordhoff's *History of California* and soon set forth to work his way to Panama as a seaman. He walked across the Isthmus to save the $25 railroad fare and then worked his way to San Francisco, arriving there in February, 1877. He soon set out on horseback for Los Angeles.

Before long he had a job in Los Angeles keeping open the water ditch that flowed from the Los Angeles River at a point opposite Griffith Park and carried water to a reservoir in Elysian Park. While doing this work, Mulholland lived in an old house at the intersection of Los Feliz Boulevard and Riverside Drive and it is here that the monument will be erected. It was here that Mulholland spent his evenings studying textbooks on mathematics, hydraulics, geology and other subjects that later he put to practical use.

Under his leadership an army of 5,000 men labored for five years to

(*Continued on page 16*)

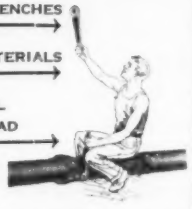
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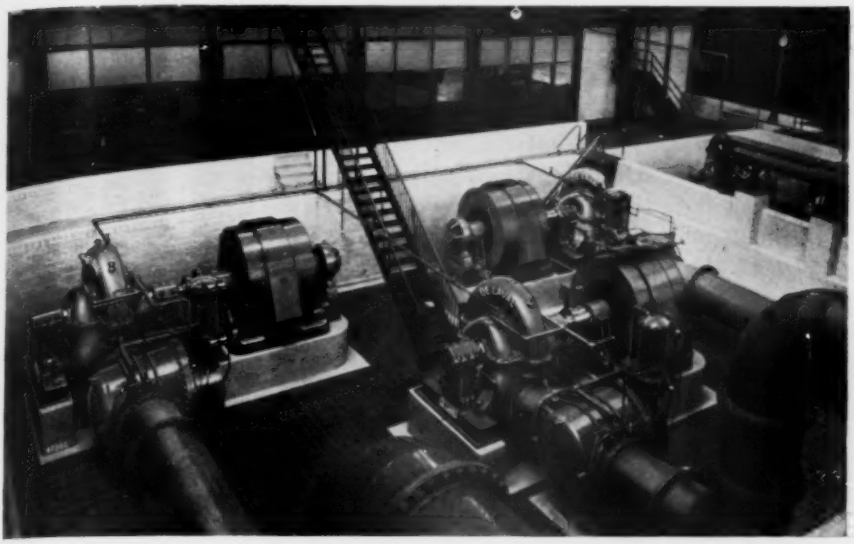
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Corrosion
Pitting
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Painting
below the water line.

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FREMONT, OHIO



Buffalo's water supplied by DE LAVAL PUMPS

THE main pumping equipment of the Colonel Francis G. Ward Pumping Station, Buffalo, N. Y., consists of three De Laval motor-driven centrifugal pumps rated at 50 m.g.d. each against 97½ lb. pressure. These units meet the normal demand, and five triple-expansion steam pumping engines of the same total capacity which were formerly used are held in reserve. The motor-driven pumps were guaranteed to show an overall wire-to-water efficiency of 85.529 per cent, which on the official acceptance test was substantially exceeded. With power at $0.00482 per kw.hr., the cost of pumping is $3.80 per million gallons.

The municipal water works systems of the United States employ more than 15,000,000,000 g.p.d. capacity of De Laval pumps.

State your pumping requirements, so that we may submit engineering recommendations and send descriptive literature.

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DE LAVAL Steam Turbine Co.
TRENTON, N. J.
MANUFACTURERS OF STEAM TURBINES, PUMPS—CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, CENTRIFUGAL BLOWERS AND COMPRESSORS, WORM GEARS, HELICAL GEARS, HYDRAULIC TURBINES AND FLEXIBLE COUPLINGS · · · SOLE LICENSEE OF THE BAUER WACH EXHAUST TURBINE SYSTEM

(*Continued from page 14*)

build the 238-mile aqueduct from the Owens River to Los Angeles. Foreseeing the need for yet another water supply source, Mulholland, by then 68 years old, personally initiated the six-year survey of 50,000 sq.mi. of desert that resulted in recommendation for the route ultimately adopted for the Colorado River Aqueduct.

The memorial will be situated on a site 1.35 acres in area. It will be an electrically illuminated water fountain, circular in shape and designed so as to display to its maximum beauty the large quantity of water available without waste and costly pumping. The reflection pool will be 90 ft. in diameter and the highest water jet will rise 45 ft. in the air. The total flow of the fountain will be about 2,250 gallons per minute. The water will flow through 134 small jets and 8 six-inch ports. There will be a series of 43 submerged projecting flood-lights designed to produce a kaleidoscopic effect upon the water at night. All maintenance of the hydraulic, electrical and landscaping features of the memorial has been permanently provided.

Officers of the William Mulholland Memorial Committee are: Joseph Scott, Chairman; Thad M. Erwin, Secretary; James R. Martin, Treasurer; and Glenn M. Desmond, Publicity Director.

(*Continued on page 18*)

THE STANDARD
for more than
50 YEARS

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Automatic Pressure Control Valves

Pressure Reducing-Altitude

Surge-Relief and Combination Valves

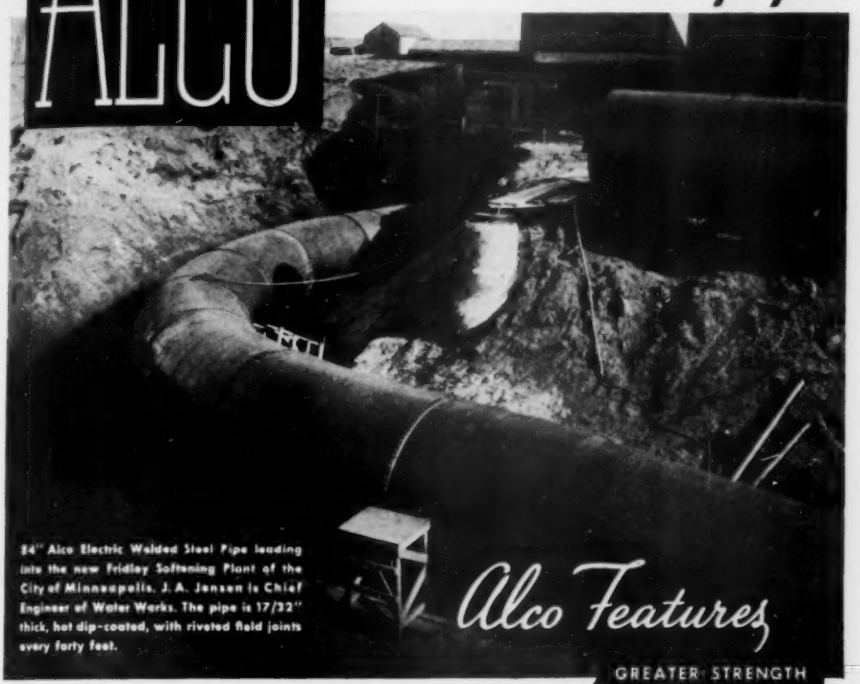
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ELECTRIC WELDED *Steel pipe*



84" Alco Electric Welded Steel Pipe leading into the new Fridley Softening Plant of the City of Minneapolis. J. A. Jansen is Chief Engineer of Water Works. The pipe is 17/32" thick, hot dip-coated, with riveted field joints every forty feet.

Alco Features

GREATER STRENGTH
LONGER LIFE
SMOOTHER WATERWAY
LONGER LENGTHS
FEWER FIELD JOINTS
LOW INITIAL COST
ULTIMATE ECONOMY

• Since 1897 Minneapolis has been using steel pipe and now has more than 200,000 feet of it over 30" in diameter in water works and sewage service. All this pipe is in excellent condition. The maintenance cost during 41 years of service has been practically nil—no breaks, no shutdowns for repairs.

Why not be guided by the experience of this progressive city?

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INCORPORATED IN U.S.A. WITH LIMITED LIABILITY
ARTILLERY HOUSE, ARTILLERY ROW, LONDON, S. W. 1, ENGLAND

(*Continued from page 16*)

Swimming pools and sinus are discussed by "Doctor Jones" who is quoted below from the September 25, 1939, issue of Health News, publication of the New York State Department of Health: "This past summer some of us were watching a youngster swimming and I agreed with the rest of 'em: she was 'a regular little fish.' But, you know, I got to thinking afterward: she was regular, all right and she was little and the way she handled herself in the water—she'd give a fish a run for his money but, just the same, it's a good thing for us humans to remember: water isn't our 'natural habitat,' as the fellow says. Take even Johnny Weismuller, there: if he had to choose between spending all his time in the water or in the trees, he'd do better in the trees.

"What brought it to mind: I was reading an article by a doctor—he's a nose, throat and ear man down in Florida—that's made quite a study of the connection between swimming and sinus and ear trouble. He brought out some things there I hadn't thought of.

"Of course water that's badly contaminated—most everybody knows it's liable to cause ear trouble where the drum's been perforated. That's why they advise using ear plugs. And getting it in your nose—it may lead

(*Continued on page 20*)

American Water Works Association
60th Annual Convention
Kansas City, Mo., April 21-25, 1940

Scheduled Hotel Rates

Rooms	Phillips	President	Muehlebach
Single Bedroom	$2.50- 5.00	$2.50- 5.00	$3.50- 6.00
Double Bedroom, 2 persons	4.00- 8.00	4.00- 6.50	5.00- 8.00
Twin Bedrooms, 2 persons	6.00- 8.00	5.00- 8.00	6.00-10.00
Suites			
Parlor and 1 Bedroom	12.00-15.00	15.00	15.00-25.00
Parlor and 2 Bedrooms		20.00	21.00
Parlor, Dining Room and 2 Bedroom			35.00
Parlor and 3 Connecting Bedrooms	25.00		
Parlor and 4 Connecting Bedrooms	35.00-40.00		

Reservations Now Being Made

LIQUID CHLORINE
"The Great Purifier"



AT the turn of the century, when Chlorine was first introduced as a water purifier, there ensued a widely publicized lawsuit to prevent its use. Curiously enough, instead of preventing its use, the facts of the case so clearly demonstrated Chlorine's value for purifying water that all doubt was forever allayed in the public mind.

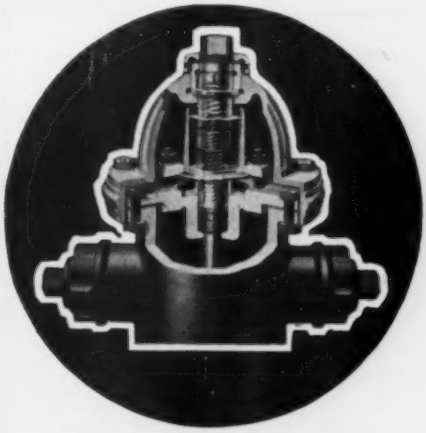
Today, over 75% of the drinking water of America is chlorinated and the typhoid rate is the lowest in history. well. Its merits require no further selling.

But the test of a service is its availability in times of emergency. Solvay's new "Big 3" Liquid Chlorine Service is designed to fulfill that test. Modern plants, the latest production equipment, a well equipped Technical Service assure State and Municipal authorities of quick and adequate supplies of Solvay's Liquid Chlorine and good advice and technical assistance when required.

Solvay Liquid Chlorine shipments are now routed from Syracuse, New York; Hopewell, Virginia; and Baton Rouge, Louisiana. Your inquiries on Solvay Liquid Chlorine are cordially solicited. Please write to

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SOLVAY
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1. **Insures easier turning of the operating nut since the threads and collar are always lubricated.**
2. **Prevents corrosion of parts, since they are constantly immersed in oil.**
3. **Eliminates excessive wear of parts because an oil film between surfaces prevents friction.**
4. **Oil is non-freezing to minus 60 degrees and since all parts are in an oil bath, no ice forms (from atmospheric condensation) to make moving parts in-operative.**
5. **Oil reservoir and packing gland being of one piece, oil seeps from reservoir on top of hydraulic packing, keeping it moist and prevents its drying out which would cause leakage.**

MUELLER CO.
CHATTANOOGA, TENN.

(*Continued from page 18*)

to sinus infections. But it seems the water don't necessarily have to be contaminated. He'd had several cases that apparently came from swimming in a big spring-fed, natural pool where the water was practically pure, according to the analysis. It looks like the irritation from the water lowered resistance in the mucous membranes and the germs that were already in their noses got in their work.

"He's found out, this doctor has, that water animals and birds, their noses and ears—if they have 'em—well, take the alligator, for instance: his nose is equipped with muscles that close it up, like a submarine, when he goes under water—so the water can't get in. Of course a first-class swimmer—a man, that is—he's learned to breathe out through his nose under water and that amounts to the same thing—while the air holds out, anyway.

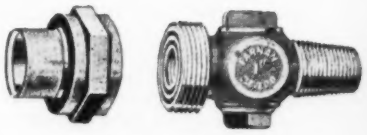
"Chilling the body—that's another thing that lowers resistance to these ear and sinus infections. He claims water takes up heat from the body twenty-seven times faster than air. He experimented with 250 children, this doctor did, and found that after they'd been in the water forty-five minutes, in 220 of 'em their body temperature was down—some of 'em to as low as 95 degrees. We're not like some of these arctic water

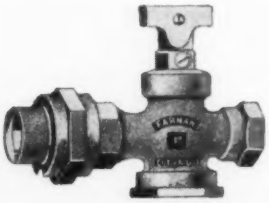
(*Continued on page 23*)

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(*Continued from page 23*)

A water main clogged with paraffin, a startlingly graphic example of dangers from cross-connections, is reported by the Cleveland Plain Dealer. Numerous consumers recently telephoned that they could get no water and workmen soon found a long length of 6-inch pipe and approximately 600 ft. of 8-inch filled solidly with paraffin. Explanation: A Standard Oil Company plant employee had opened the wrong valve and the paraffin had rushed forth to fill the mains which reportedly have a water pressure of 40 lb. per sq.in. Paraffin is relatively innocuous, but imagine a cross-connection as potential as this with discharge from a slaughter house—or from many places you may imagine.

The National Association of Railroad and Utilities Commissioners has published three mimeographed bulletins of special interest in the water works field: (1) "Interpretations of Uniform System of Accounts for Water Utilities," Bulletin No. W-1, 24 pp.; (2) "Interpretation of Uniform System of Accounts for Water Utilities," Bulletin No. W-2, 19 pp.; (3) "Rules Governing the Preservation of Records of Water Utilities," 22 pp. Each of these bulletins was prepared by the Committee on Statistics and Accounts of the N.A.R.U.C. Any member of the A.W.W.A. wishing copies of the above may obtain same by sending to A.W.W.A. headquarters 55 cents for each copy wanted.

"The 1939 Report of the Special Committee on Depreciation" is now made available in mimeograph form by the N.A.R.U.C. It is 74 pages single spaced and can be obtained from A.W.W.A. headquarters for $1.55 per copy. This document will be available in printed form at a later date.

(*Continued on page 28*)

Trade Mark MABBS Reg. U. S. Pat. Off.
PREVENT WEAR AND CUTTING of rods, plungers and shafts by using
MABBS RAWHIDE PACKING
on your Water Works and Sewage pumps and valves. Practically antifrictional, it saves enough in POWER to pay for itself in a short time. For over 45 years Mabbs Rawhide Packing has proven its superiority over other packings for these purposes.
Why not use it in your plant and benefit thereby?
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GRAPH & NOMOGRAM

from

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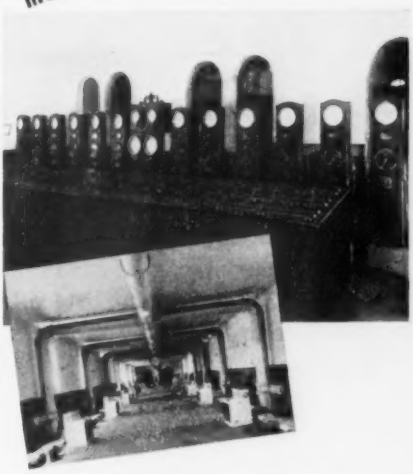
American Water Works Association

22 East 40th Street

New York City

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METERS & CONTROLLERS AT MONTREAL



VENTURI Type M Register-Indicator-Recorders stand, like sentinels on guard, behind the bench-board in the Chief Operating Engineer's room at the Atwater Main Pumping Station and at the McTavish Street Pumping Station.

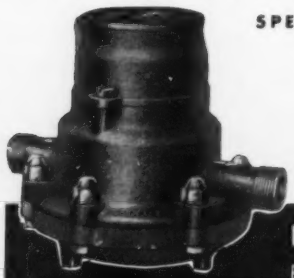
Likewise, at the Filtration Plant, forty-eight 20″ Venturi Rate-of-Flow Controllers have been giving satisfactory service for years, doing their bit to maintain Montreal's enviable record for producing pure water at low cost.

We shall be glad to discuss the application of Builders Venturi and Chronoflo Equipment to your needs; address

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(BRONZE CASE) (IRON CASE)
Water Meters
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(*Continued from page 26*)

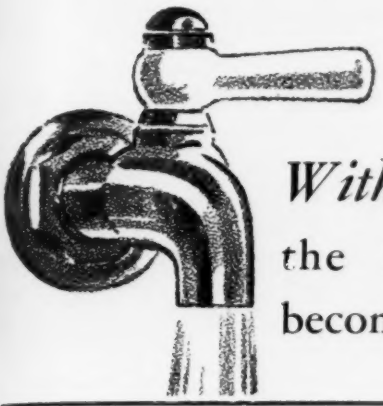
This report, which the Committee states is a progress report, consists of the following chapters: (1) Accounting and Financial Aspects of Depreciation; (2) Appraisal Aspect of Depreciation; (3) Replies to Questionnaire made by regulatory authorities, appraisal firms and others named by classes asking for expression of views upon ten numbered conclusions contained in the Committee's 1938 report. An Appendix contains comments of the Depreciation Committee of the Edison Electric Institute prompted by the Committee's Questionnaire.

Also published by the N.A.R.U.C. is the "Revised Annual Report Form for Water Utilities" which is coordinated with "Revised Uniform System of Accounts for Water Utilities," adopted at the 1938 Convention of the N.A.R.U.C. This can be obtained from A.W.W.A. headquarters for $2.05.

"Stream-Gaging" Stations Provide Data on Nation's Water Resources. Assistance given to a number of states in constructing additional river-measurement or "stream-gaging" stations and in improving existing ones, under a joint program of the United States Geological Survey and the Work Projects Administration, has been a valuable but little publicized activity. Such projects have been operated in approximately a score of states. Stream-gaging stations keep a constant record of the nature of rivers and streams and thus obtain data essential to all water resources investigations. There are now located along the rivers and streams in more than 45 states approximately 4,000 river-measurement stations which are operated under the supervision of the United States Geological Survey. At these stations data are assembled regarding the stage and flow of the rivers.

The question of how much water the nation has as a natural resource does not bother the average citizen except during a flood or drouth. Then he is quite sure of the answer. It is either "too much water" or "not

(*Continued on page 30*)



With **HYDRODARCO**
the Palatability Problem
becomes as simple as A-B-C

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A High Activation

B Free Feeding in the plant . . . .
Hydrodarco works well in dry feed machines

C High Taste and Odor
Removal per dollar of cost

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• MARSHALL, TEXAS •
• MONTREAL, CANADA •

(*Continued from page 28*)

enough water." Essential to the control of these periods of flood and drouth is a detailed knowledge of the stages and quantities of flow, over a period of time. Through these stream-gaging stations, and through periodic flow measurements at intermittent points, detailed knowledge is obtained.

The design of all hydraulic structures, navigation on inland waters, irrigation systems, municipal water supplies, power and industrial-plant development, and planning for the storage of water, are only a few of the other developments which depend upon the availability of water and adequate information concerning the sources of supply.

The need for accurate knowledge of river and watershed characteristics has grown considerably during the past few years as floods have become more frequent and as wider planning to control them has been instigated. Too, the increased construction of power dams and hydroelectric plants has called for more and more accurate data regarding stage and flow characteristics of the streams and rivers to which they are related, and which furnish the power.

Thus the growing awareness of the general value of stream-flow data

(*Continued on page 32*)



STRONG - TIGHT AND FLEXIBLE!

Regardless of where you lay cast iron water mains —under paved streets, railroads or over bridges— you can depend on HYDRO-TITE to make joints that are not only strong, tight and flexible but "lasting". HYDRO-TITE is easy to prepare and use. It has a record of over 25 years without a single failure anywhere.

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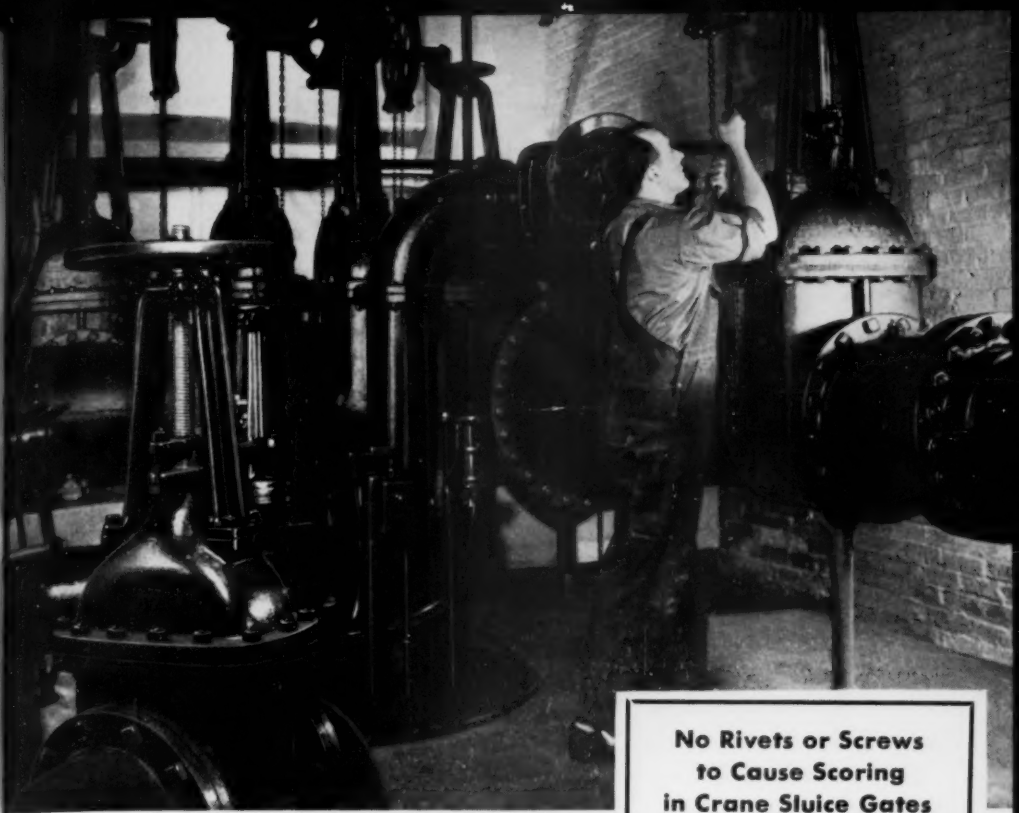
Main Sales Office: 50 Church Street, New York, N. Y.
General Offices and Works: West Medford Station, Boston, Mass.

HYDRO-TITE

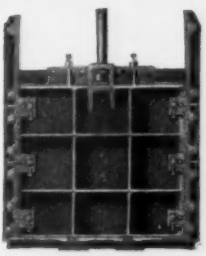
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A Symbol of Quality

A DEPENDABLE SELF - CAULKING JOINT COMPOUND



No Rivets or Screws to Cause Scoring in Crane Sluice Gates



There are no rivets or screws in Crane Sluice Gate seats to work loose and interfere with smooth operation—to cause burrs that cut deeply into seating surfaces. The Crane method of seat mounting avoids this danger. Crane bronze seats are rolled into dovetail grooves of ample section machined in the face of the disc. After rolling seat facing into the grooves, seating surfaces are machined to a smooth tool finish.

That's just one of the many reasons why Crane Sluice Gates give superior service—smooth and positive through long years. Crane's vast experience and facilities in engineering water control equipment back up the dependability of every part—frame, disc, guide rails, operating mechanism—assure faithful performance. Consult your Crane Representative.

CTION *When You Need It!*

ith CRANE Water Works Valves

OUR water supply plant is a 24-hour day business—with exigent situations always threatening. And for control of most emergencies you must look to valves.

Because, as a rule, valves in water works are infrequently erated, with the disc in open or closed position for long riods, unfailing response must be assured when it is necesy to shut off or divert flow.

And because Crane valve design gives recognition to such rvice, and Crane engineering provides the resistance to chanical strains, and corrosive effects both inside and out, u can depend on Crane valves for smooth, positive action en you want it.

Consider the need of Crane-Quality valves from the standnt of maintenance. You know the cost of valve replacents, especially on large lines—the dangers of interrupted eration. The extreme accuracy with which Crane valves e built—the careful analysis and specification of materials at go into every part—and Crane's 84-year manufacturing perience—assure enduring, economical performance.

What's more, Crane supplies the *right* equipment for every w control service in pumping stations, filtration and sewe plants. Enjoy the advantages of one high standard of ality—one source of supply—and one responsibility for all ur piping needs. Choose them from the 38,000 items in ur Crane No. 52 Catalog.

CRANE

CRANE CO., GENERAL OFFICES
836 S. MICHIGAN AVE., CHICAGO
VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

(*Continued from page 30*)

and the pertinency of such data to the expanded operations of a number of agencies, both governmental and private, are behind the program for the establishment of additional gaging stations. Both the state and federal governments have cooperated in supplying funds for new stations and for adding additional or new equipment to existing ones. In addition to those added with the aid of the W.P.A., many others, now operated by the Geological Survey in cooperation with the U. S. Weather Bureau and the U. S. Corps of Engineers, recently have been established. Both of these agencies need stream-flow data in their operations. The U. S. Corps of Engineers uses such information in its flood control work, and in navigation developments. Stream-flow data coupled with information regarding the water sheds to which the various streams are related is very useful to the Weather Bureau in its many operations.

W. P. A. projects for the establishment of new stations and for improvement of existing ones, many of them on a statewide basis, have been operated in the following states: New Jersey, Virginia, Tennessee, Alabama, Mississippi, Louisiana, Kentucky, Illinois, Missouri, South Dakota, North Dakota, Arkansas, Florida, Indiana, Massachusetts, Texas, and

(*Continued on page 34*)

THE FORD METER
MITTEN
WILL SAVE FROZEN METERS

Made for meters up to 1" in size.



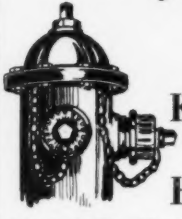
Simple and easy to install.

The Meter Mitten is a convenient and effective insulation jacket for basement meters. Conserves warmth in meter and water and prevents many meters from freezing. Costs but a fraction of the expense of a frozen meter. Write for further information.

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WABASH, INDIANA

For over 50 years
O.K.'d
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on the job



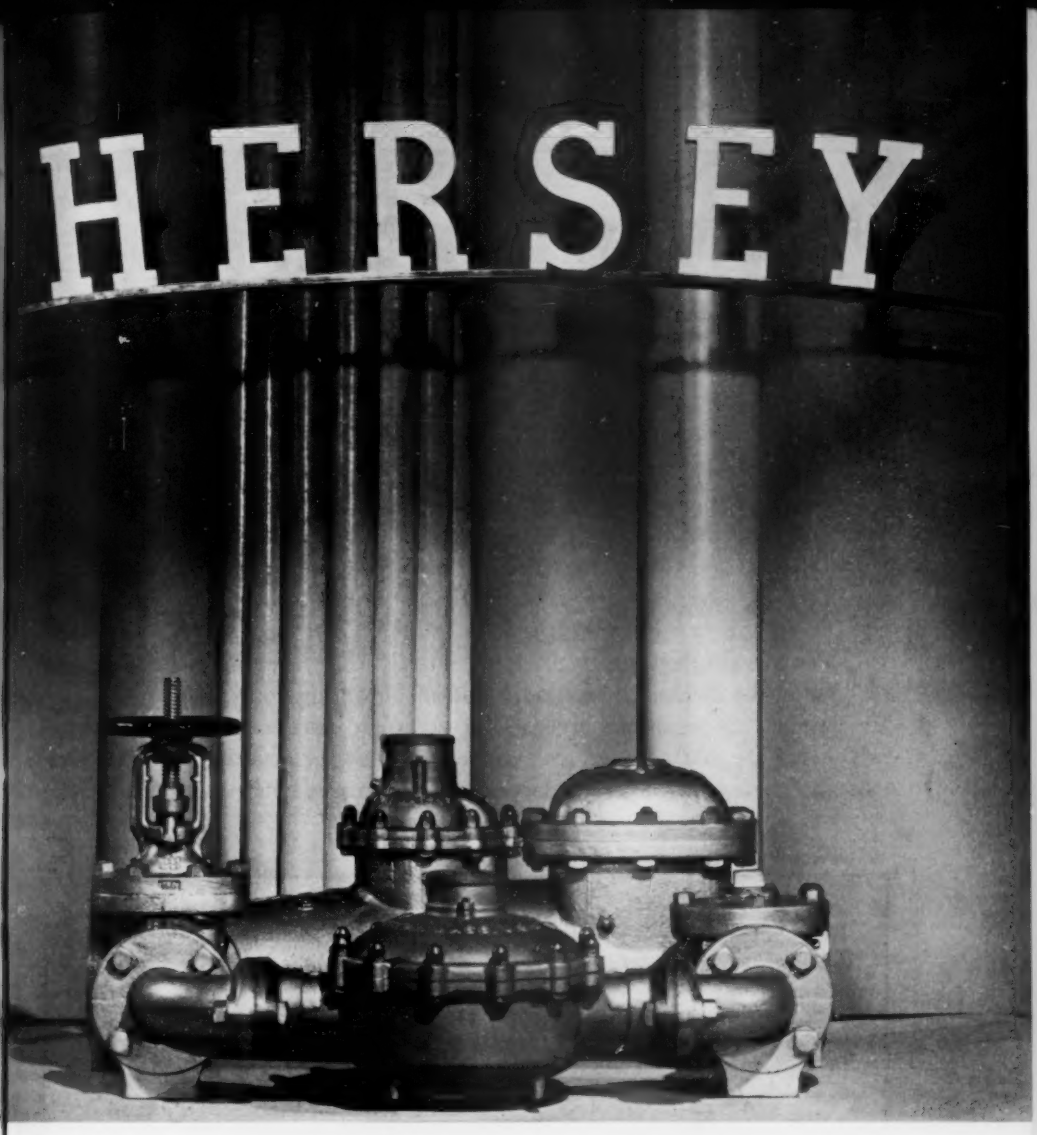


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FIRE
HYDRANTS

Kupferle Fire Hydrant No. 100 has been tested and approved by the Board of Fire Underwriters and complies with the specification of the A.W.W.A. *Specification sheets sent on request.*

JOHN C. KUPFERLE FOUNDRY CO.
ST. LOUIS

KUPFERLE



HERSEY DETECTOR METERS

continue to win the acceptance of Leading Water Works Officials throughout the country, because of their accuracy and absolute dependability. They are approved by the National Board of Fire Underwriters for their unrestricted delivery in case of fire.

Hersey detector meters are safeguarding water works interests on over a billion dollars worth of insured property.

HERSEY MANUFACTURING COMPANY
SOUTH BOSTON, MASS.

BRANCH OFFICES: NEW YORK—PORTLAND, ORE.—PHILADELPHIA—ATLANTA—DALLAS—CHICAGO—SAN FRANCISCO—LOS ANGELES

COOK Well Strainers

A reciprocal relation, the life and functioning of the one depending much on the other.

A. D. COOK, INC.
Lawrenceburg - Indiana

COOK Deep-Well Turbine Pumps

(*Continued from page 32*)

Vermont. All of these projects were sponsored by the U. S. Geological Survey. Such State organizations as Water Resource Boards, Public Utility Commissions, and State Planning Boards have cooperated extensively in this work.

As a part of its activities the Geological Survey has pioneered in developing and improving the methods and techniques that are necessary to accurate water resource investigations. Tests toward improving such equipment are in constant progress at the U. S. Bureau of Standards.

The stream-gaging process is essentially that of determining the rate of flow or the discharge of a river and of obtaining continuous records of the various stages of the river. For complete and accurate data, determinations are made of the average rate of flow for a period of time, such as an hour, day, month, or year, and of the changes in the rate of flow from

(*Continued on page 38*)

A.W.W.A.

Membership Certificate

A fine newly designed parchment paper mempership certificate for A. W. W. A. members is now available in 9 by 12 inch size, suitable for framing.

Send your name—exactly as you wish it to appear—and enclose 40¢ in coins or postage to cover cost of lettering and mailing.

The certificate will be delivered within 10 days of receipt of order—ready for you to frame and hang in your office.

American Water Works Association
22 East 40th Street, New York City

SYSTEM OF SAFETY STAND WATCH OVER *Your Community*



LIQUID CHLORINE that virtually eliminates chlorinator irregularities now offers the water works new dependability in its day-to-day operation. Another product, Perchloron, stands ready to act as your second line of defense in time of emergency. Together these two products bring you the Pennsylvania Salt System of Safety for protecting the water supply.

The purity of this liquid chlorine is a great advance, made possible by a new purifying process developed by Pennsylvania Salt. Specially designed fractionating equipment substantially removes trouble-making impurities, and their cumulative effect over long periods of operation has been minimized.

In addition an improved analytical method of evaluating liquid chlorine as to such impurities was developed as a means of manufacturing control. This is an extra safeguard for your protection, a further assurance of trouble-free operation of your equipment.

You will appreciate Perchloron, the second safety-product, in case your normal supplies of liquid chlorine are ever cut off by some unforeseen event—such as a flood, hurricane, blizzard, or conflagration. Perchloron is a dry, free-flowing granular material containing more than 70% available chlorine. It dissolves readily in water. Stable, concentrated, uniform. Packed 9 handy-sized cans to the case, each can with new Kork-N-Seal cover. Also in 75-lb. drums.

Perchloron is used, not only for emergency chlorination, but for sterilizing new mains, for clear wells and filters, and for swimming pool sanitation. Write for free illustrated booklet. Pennsylvania Salt Manufacturing Company, Widener Building, Philadelphia, Pa.—New York • Chicago • St. Louis • Pittsburgh • Tacoma • Wyandotte.

PENNSYLVANIA SALT
MANUFACTURING COMPANY
Chemicals

(Continued from page 34)

day to day; also of the rate of flow corresponding to a given stage, regardless of time.

In order to obtain this data the modern stream-gaging station usually has a water-stage recorder, sheltered by a concrete structure; and in the vicinity some means, such as a cableway, bridge or other suspension device, from which accurate flow or water-velocity measurements may be taken. Artificial controls constructed in the river are sometimes necessary to assure more stable conditions.

Part of the procedure used in gaging the flow of streams in open channels consists of making individual measurements of discharge (rate of flow) at various stages from low water to high water. From this record a relationship known as the stage-discharge relation is worked out. Once the stage-discharge relation is known for a particular station it is possible to obtain records of discharge from the daily records of stage that are collected by the stage-recording device.

However, in order to arrive at a satisfactory determination of the relationship of flow to the stage of the river and to obtain one that will be reasonably permanent, the nature of the river channel at the station point

(Continued on page 40)

Warren Foundry & Pipe Corp.

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Sizes 2″ to 84″

Flanged Pipe ***Flexible Joint Pipe***

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Special Castings ***Short Body B. & S. Specials***

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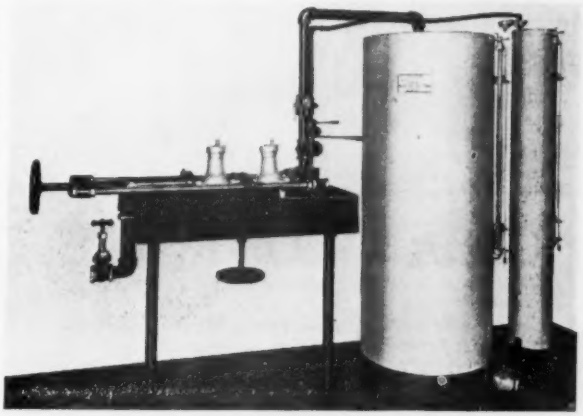
Large Stock Enables Us to Make Prompt Shipments

Are you one of those Water Works men?

"It is quite surprising that in far too many water works plants very little attention is paid to the water meter after it has been installed," says Mr. HENRY HORANDT, C.E., Meter Engineer, Federal Water Service Corp. and Manager, Water Service Corp., Brooklyn, N. Y. **"In some localities meters actually are allowed to remain in service until such time as they fail to register. There are managers... who have little if any knowledge of ...the very instruments upon which they depend for revenue."**

A well-known authority considers TESTING·WATER METERS as all-important

Again quoting Mr. Horandt: "The testing of Water Meters may be considered as one of the most important problems relating to Water Meter practice . . . in this day and age requiring comparatively low rates of flow coupled with the great amount of attention now being paid to meter accuracies and sensitivities . . . The day is at hand when the Water Works Superintendent wants to know more about his water meters."

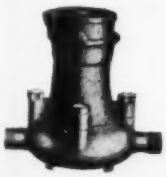


General view, Test Bench No. 15. Note compact simplicity. Two calibrated tanks, a 1 cu. ft. tank and a 10 cu. ft. tank; or a 10 gallon and a 100 gallon tank. Tests on all flows. Low cost. Larger sizes available.

Modern practice demands you· TEST YOUR WATER METERS

NEW Water Meters should be tested. A careful checkup **in your shop** often detects unsuspected inaccuracies or loss of sensitivity. It will not cost much nor take long if made on such equipment as the Neptune Test Bench. Testing used meters BEFORE REPAIRS gives extremely valuable data regarding service, renders great assistance in reducing meter maintenance costs.

THINK THESE THINGS OVER. They are of vital importance to your Water Works. A copy of Mr. Horandt's new book, **"An Outline of Water Meter Practice,"** and data on Neptune Test Benches will be sent you upon request.



NEPTUNE METER COMPANY

Manufacturers of Trident Water Meters "Cash Registers of the Water Works Field"

50 West 50th Street (Rockefeller Center), New York City.

Branch Offices in Principle Cities.

Neptune Meters, Ltd., 345 Sorauren Avenue, Toronto, Canada.

(*Continued from page 38*)

must be relatively stable. Any change in these conditions occasioned by a flood or other such disturbance or by a habitually shifting stream bed would possibly change the rate of discharge at that point. Hence artificial controls are sometimes built in the channel of the stream at the station point in order to stabilize the stage-discharge relation. While these may not be absolutely necessary, depending upon the character of the stream, such controls usually simplify the gaging procedure and increase the accuracy of the records. In some cases it may be desirable to stabilize the stream bed by means of a low structure built in the stream to conform to the general profile of the bed. Usually, however, the controls are built to a height somewhat above the natural profile of the stream bed. These usually take the form of a low broad-crested weir.

Once a reasonably stable stage-discharge relation is obtained, a rating curve or rating table is prepared which is used in converting the records of stage into records of discharge. Therefore continuous records of stage or river height are desirable. They are valuable in computing the records of discharge or flow and they are valuable in themselves. Continuous records of the variation in river height or stage over a period of time are essential to a number of investigations.

(*Continued on page 42*)

CLEAN YOUR WATER MAINS

One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

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P·DM Elevated Steel Tanks are supplied in all sizes, from 5,000 gals. to 5,000,000 gals. capacity.

P·DM Products for the American Municipality include: Elevated Steel Tanks . . . Steel Reservoirs . . . Water Treating Plants . . . Refuse Incinerators . . . Steel Swimming Pools . . . Steel Grandstands. *Bulletins gladly sent on request.*

P&DM ALWAYS ON THE JOB

Pittsburgh-Des Moines' high place in the regard of the many municipalities who have invested in P·DM Elevated Steel Tanks is maintained by the sterling performance and lifetime durability of these famous products. The thousands of P·DM Tanks serving villages, towns and cities throughout America prove to everyone's satisfaction that P·DM's "know how" is unsurpassed in modern tank design, fabrication and erection.

If improvement is desirable in your own community's water service, it will cost not a whit to have a skilled Pittsburgh-Des Moines Engineer make a preliminary survey of the problem. His broad experience has been gained in dealing with similar needs in like communities—and he will be glad to detail to you and other interested local authorities how P·DM Elevated Water Storage assures continuous water supply at uniform pressures throughout the day and year . . . how it lowers operating costs, and *betters* service for every consumer.

Let us arrange a consultation for you—and meanwhile, send you our informative 20-page bulletin on "Modern Water Storage in Elevated Steel Tanks." No obligation, of course!

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PITTSBURGH, PA. 3424 NEVILLE ISLAND—DES MOINES, IOWA, 925 TUTTLE STREET

New York, Room 921-99, 270 Broadway . . . Chicago, 1228 First National Bank Building

Dallas, 1229 Praetorian Building . . . San Francisco, 631 Rialto Building

(*Continued from page 40*)

The water-stage recorders used to collect this information consist of a time element and a height element so arranged that a continuous graph of river stages may be automatically produced on the record paper. While the structures to house the water-stage recorder are not large or expensive, they do have to be of special design and must have a particular location with reference to the river channel.

The stage-recording assembly includes a stilling well dug in the bank of the river. The stilling well is connected with the river by a 3- or 4-inch intake pipe. The depth of the well is below minimum low water. The top of the well terminates in a shelter house with a floor and support for the water-stage recorder. The structure is high enough to lift the recording device above maximum flood stages of the river. Recordings of stage are made by means of a float in the well connected to the height element of the stage-recorder by a graduated stainless-steel or phosphor-bronze tape. While the gage well and shelter house may be of timber construction, reinforced concrete is recommended for permanent construction. Staff or other non-recording gages outside and inside the well are necessary for comparing the stage of the well with that outside and for use in setting and checking the recorder. Too, the station should be located with reference to permanent bench marks so that the datum of the gage may be maintained.

In making the individual measurements of discharge or flow of the river, use is made of special equipment designed particularly for that purpose. A number of different types of current meters for use in measuring the velocity or flow of water have been designed. Those in use by the Geological Survey contain a rotating element so constructed that when placed in flowing water the number of rotations in a unit of time will be proportional to the velocity of the water. Individual flow or velocity measurements are usually taken from a bridge or from some other vantage point above the stream. However if a low stage of water causes unfavorable conditions for accurate velocity determinations at a bridge or cable location, measurements are sometimes made by wading out into the stream at a more favorable point.

The data obtained at these stream-gaging stations are published and made available for general use by the Geological Survey. These records may be in the form of tabulations which show the average daily discharge of a river or stream for each day of the year. Or the essential facts may be given in tabulations of average, minimum and maximum discharge for each month of the year. Other data showing monthly or yearly runoff in second feet per square mile, runoff depth in inches from the drainage area, and runoff in acre feet are also computed. From this information various hydraulic studies corresponding to the needs of individual problems may easily be made.

NEWS OF THE FIELD

4000 A. W. W. A. members in 1940 is an objective, the attainment of which can be expected by convention time.

October, 1939 turned out to be one of the banner months for membership gain in A. W. W. A. history.

The year has been moving along, piling up a substantial increase in members. At the first of January the total was 3,359. The year before, it was 3,064, and the year before that, 2,724. By September 30, 1939, the total had reached 3,644—a gain of 285 since January first. With October came a series of Section meetings—Four States, West Virginia, Southwest, New Jersey and California. A renewal of activity was evident in all quarters.

It remained for the Southwest Section figuratively to tear the lid off. A membership promotion committee has been active under the leadership of Section Chairman-elect Cunningham of Oklahoma City. The meeting at Dallas started with 121 members in the Section. When it was over, 83 new names were on the roll. Other areas were not at rest. Ten from California, 8 from North Carolina and 46 from the rest of the field brought the total number of applications received during the month to 137.

November will start off with a big group from California and the North Carolina, New York and Wisconsin Sections are not by any means asleep at the wheel.

Flash: At the close of the San Francisco Meeting, The California Section membership totaled an even 500.

The best feature of it all is the fact that the growth is not the result of over-selling or promotion—but the simple evidence that water works men the continent over are convinced that the A. W. W. A. is doing things for the field and they want to have a part in the doing of it.

"**A Municipality Confesses**" is the caption under which the Wall Street Journal carried an editorial discussion of the recent negotiations concerning possible administrative management of the Louisville Water Department by the American Water Works and Electric Company.

The underlying facts are that the city of Louisville faces a severe problem of meeting its sinking fund obligations. Mayor Scholtz appointed a special committee to study the situation. The net results of the study were two recommendations, one to institute certain license taxes estimated to produce $553,000 annually, and the other to increase the net revenue to the city from the water department operations by $500,000 annually.

(Continued on page 2)

(*Continued from page 1*)

The Louisville Water Company name was carried forward when the city took over control of the property many years ago. The water board form of management of the property was established, but the board as a continuing body does not appear to have developed the intelligent support of the citizens that it needed. A program of complete metering was delayed by the obstructive influences. A revision of the rate structure proposed about two years ago aroused a storm of protest.

So, when the Mayor's committee recommended that the water department be the source of an additional half million net to the city's general fund—the idea developed that private management might be the answer.

The American Water Works and Electric Company was requested to examine the situation, and did so. The company reported its willingness to manage the property under clearly defined terms too long to recount here. It was definitely indicated that the management fees would accrue from the savings resulting from administrative policies established by the management company.

The proposal has neither been accepted nor rejected (as of November 1) but the fact that the discussion has been held merits comment.

(*Continued on page 4*)

Colonel John C. Michie, Superintendent of the Durham, N. C., Water Department, died on October 18 at his home in Durham. He was born in Rockland County, Va., in 1862. He attended Virginia Military Institute, from which he was graduated in 1887 with a civil engineering degree. Employed as an engineer by the Norfolk and Western Railway, he came to Durham in charge of a party which made perliminary surveys and worked on the construction of the old Lynchburg and Durham Railroad. He supervised construction of the railroad and after its completion was in charge of laying a belt line around the city. Subsequently Col. Michie established himself as a consulting engineer.

In 1892, when private interests began the water system in Durham, he became superintendent and was kept in charge when the city acquired the water system. He volunteered in the Spanish American War, serving first in the infantry and later in the engineering brigade of the second division.

Col. Michie ranked as a dean of water works engineers in North Carolina. He pioneered many worthy projects and was one of a small group that worked to form the North Carolina Section of the Association. He was among the first officers of the North Carolina Section and was Chairman in 1923–24. He had been a member of the Association since 1903.

WM H. TRENTLAGE

(Commissioner Public Health and Safety and Superintendent of Water Dept., Elgin, Illinois)



says:

"We have a 16" cast iron water main, laid in 1887, that extends from our pumping station to the elevated tank across the river, a distance of $2\frac{3}{8}$ miles, on which we have spent only $22.03 for repairs and maintenance during the last 6 years, or $1.53 PER MILE. We recently removed 13,119 feet of small diameter cast iron mains that had been in service 52 years. These were replaced with larger cast iron mains and 12,900 feet of the old mains were relaid in outlying districts. The remaining 219 feet was sold for scrap iron."

Wm H. Trentlage

Water mains represent about one-third of this country's 5-billion-dollar investment in public water supply systems. More than 98% of these mains are cast iron pipe with a *known* useful life at least double the *estimated* life of other water main materials. Because the tax-saving, through deferred replacements alone, is enormous, cast iron pipe is known as Public Tax Saver No. 1.

CAST IRON

Look for the "Q-Check" Registered trade mark.
Cast iron pipe is made in diameters from 1¼ to 84 inches.
The Cast Iron Pipe Research Association, Thos. F. Wolfe, Research Engineer, 1015 Peoples Gas Building, Chicago, Illinois

CAST IRON PIPE
PUBLIC TAX SAVER NO. 1

(*Continued from page 2*)

First, the idea is not new. Private administration of publicly owned enterprises has been tried in Europe and found to meet the needs of certain situations. One large gas property has been thus managed in this country for many years. When the conditions are right, such a policy can be effective.

Second, in contrast, it cannot be denied that there are conspicuous successes of public ownership and management under citizen-board control. It requires the disinterested and unselfish service of business men of leadership qualities. It requires that they be given full authority to manage the property just as the directors and management staff of a private property are allowed to proceed. It can be and has been so routinized that the water department sets aside proper reserves for depreciation and pays the city general fund annual dividends just as a corporation's stockholders receive dividends.

But it is not easy—simply because the average American has not yet learned that publicly owned technical service enterprises cannot be politically managed and succeed.

It is too seldom true that a city is able to combine intelligent public

(*Continued on page 6*)

For Underground Service Lines

ANACONDA COPPER and RED-BRASS



Anaconda Copper Tubes in straight lengths and coils... Anaconda "85" Red-Brass in straight lengths only – both are products of dependable quality. Made by the world's largest and most experienced manufacturer of copper and brass, and stocked by leading supply houses.

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THE AMERICAN BRASS CO.

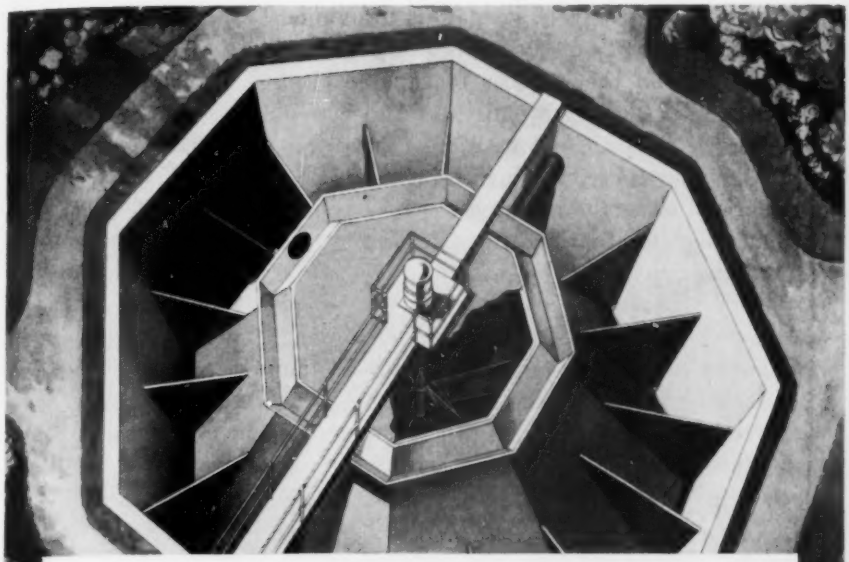
General Offices: Waterbury, Connecticut



ONE SEAL-ONE STEP



Permutit Spaulding Precipitator
for Iron-Free Soft Water



Everything a water treatment should be . . . simple, efficient, economical

FEATURES:

1. Sludge is kept suspended . . . this speeds precipitation, also acts as a contact filter.

2. Conical filter chamber . . . this lowers velocity of water as it rises, keeps sludge uniformly dense for efficient filtering.

PERFORMANCE:

Takes less than half the space needed for old design cold lime treatment. Takes less time, less chemicals. Yields a clear, sparkling effluent, so stable that recarbonation is often unnecessary!

RECORD to DATE:

More than 20 plants, ranging in size from 5,000 to 8,000,000 gallons per day installed within the last few months!



16-PAGE BOOKLET FREE:

Diagrams, layouts, actual installations, full information. No obligation . . . address The Permutit Company, Dept. G2, 330 West 42nd St., N. Y.

PERMUTIT

WATER CONDITIONING *Headquarters*

(*Continued from page 4*)

support of publicly owned enterprise with the services of men as board members who fully appreciate the nature of a public trust. It takes just that sort of combination to make public ownership really effective.

There is quite a body of vociferous individuals who are willing upon all occasions to point out the virtues of public ownership, but it is highly difficult to obtain the services of capable citizens to act upon public boards and plan long term policies. And it is doubly difficult to obtain such services against the competition of men who seek to be thus appointed so that they may serve their selfish interests.

American cities for many years have been challenged by this issue. And the Louisville situation brings it sharply to the fore again for here this city, and vicariously every other city, is faced with the question: can we set ourselves to manage satisfactorily the business of water supply, the business which is so largely under municipal management, which so many of us smugly assume is an inherent right of municipal management and which so many make a tragedy of managing? Los Angeles, Omaha, Des Moines, Appleton and other cities have shown that it can be done. The roll of cities that have as yet failed need not be listed here.

(*Continued on page 8*)

3 *Money Time and Labor Saving Features of*

UNIVERSAL CAST IRON PIPE

LAID WITH ONLY WRENCHES →

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For water supply, fire protection systems, sewage disposal systems, industrial, and irrigation. Flexible. Tight joints.

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Gentlemen: Send us information and catalog on UNIVERSAL CAST IRON PIPE.

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Help save these lives! Your dollar will do this. In addition, you will receive a supply of Package Labels, and our Quarterly Review giving you the latest information on cancer.

N.Y.C. CANCER COMMITTEE
of the American Society for the control of Cancer, 130 East Sixty-sixth Street, N. Y. C.

For $1 enclosed, please send me a supply of your Package Labels. I understand that in addition you will send me your Quarterly Review.

Name _____

Street _____

City _____ *State* _____

Persons living outside New York City and Long Island may write for local information to headquarters: American Society for the Control of Cancer, 350 Madison Avenue, New York.



Hot water heater coil clogged with calcium carbonate scale! Threshold Treatment prevents this!

THIS remarkable new product is called Calgon. It's so effective that as little as one part per million in hard water prevents the formation of calcium carbonate scale in hot water lines and heater coils. A similar amount of Calgon is effective in controlling corrosion. Where softening plants are used, Calgon stops the encrustation of filter sands and after-precipitation in the distribution system.

It's almost unbelievable that these age-old problems can be solved so easily, but the facts have been definitely established in actual practice. This method is called Threshold Treatment.

Only small amounts of Calgon are needed — one or two pounds are enough for 100,000 gallons of water. No elaborate dosing equipment is necessary, so the cost of Threshold Treatment is always low.

We'll gladly send complete information. Just mail the coupon.

CALGON, INC.

SUBSIDIARY OF HAGAN CORPORATION

Chemical and Combustion Engineers

Calgon, Inc., 300 Ross St., Pittsburgh, Pa.
Please send information on Threshold Treatment. I am interested in ☐ scale prevention ☐ corrosion control.

Name _____

Company _____

Address _____

City _____ State _____

(*Continued from page 6*)

As further evidence of the growing "show-us" attitude of city dwellers concerning municipal management problems, it is highly significant that when the owners of the Indianapolis Water Company manifested an interest in the sale of that property to the city, after a considerable amount of study had been given to the terms of sale, the negotiations were abandoned. Underlying the ostensible reason for calling off the negotiations was the fact that informal "straw ballots" throughout the city showed a heavy majority of voters opposed to the city's undertaking the ownership and management of additional utility property.

By some this was interpreted to indicate that the people were not satisfied with the manner in which the city manages the gas utility and the sanitation plant. By others it was interpreted to mean that not alone were the citizens less than satisfied with the present municipal management operations, but that they found themselves getting good service from the water company organization and were satisfied with it.

If the Louisville negotiations looking toward private management and the abandonment of the Indianapolis negotiations for public ownership imply anything, they mean that more than the mere motions of

(*Continued on page 10*)

RUSTOP *the*

Cathodic Method of Eliminating and Preventing Rust and Corrosion in Steel Water Tanks.

Eliminates the Necessity of Painting below the Overflow.

Cleans Old Tanks. Keeps New Tanks Clean.

Now Used by Many Cities And Manufacturers. Write For List Today.

(Pat. Pend.)

ELECTRO RUST-PROOFING Company

Third National Building

Dayton, Ohio

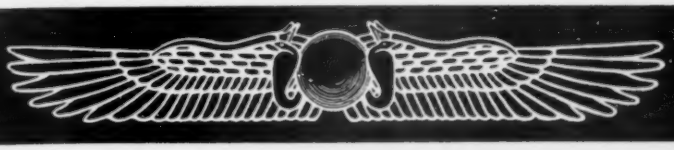
OVER 500 municipalities use American or New York Continental Jewell Water purification equipment.

WATER FILTERS
WATER SOFTENERS

Proportionate Electro-Magnetic Chemical feeders for feeding lime, acid, alum, soda ash, etc.

AMERICAN WATER SOFTENER COMPANY

Lehigh Avenue and 4th St.
Philadelphia, Pa.



WORTHINGTON
EQUIPMENT FOR WATER SUPPLY

CENTRIFUGAL PUMPS	STEAM AND POWER PUMPS
DEEP WELL TURBINE PUMPS	SUMP AND DRAINAGE PUMPS
DIESEL ENGINES	GAS ENGINES
STEAM CONDENSERS	CONDENSER AUXILIARIES
FEEDWATER HEATERS	STEAM-JET EJECTORS
STATIONARY AIR COMPRESSORS	PORTABLE AIR COMPRESSORS
ROCK DRILLING EQUIPMENT	CONSTRUCTION AIR TOOLS
V-BELT DRIVES	AIR LIFTS
STEAM TURBINES	REDUCING AND INCREASING GEARS

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WATER METERS

A complete line of water meters of every type is manufactured by Worthington-Gamon Meter Company, a subsidiary of Worthington Pump and Machinery Corporation.

● *Descriptive literature on any of these products furnished on request*

WORTHINGTON PUMP AND MACHINERY CORPORATION
WORTHINGTON-GAMON METER COMPANY

General Offices: HARRISON, NEW JERSEY *District Offices and Representatives in Principal Cities*

CDB-7C

(Continued from page 8)

management are now being expected from those in responsible control of publicly owned enterprises. Mayors, city managers and public leaders must in many cases revise their ideas of such matters and give the water plant personnel, that is trying to do a good job, the kind of support and the type of director-management that it has to have if it meets its problems properly.

Neither private ownership nor public ownership has a God-given charter to do business. Either one or the other will continue as and if it serves the fundamental public interest. Neither should expect to continue if it does not.

C. S. Patton has been appointed Sales Manager of the Alco Products Division of the American Locomotive Company in charge of the sale of heat exchangers, condensers, feed-water heaters, evaporators, tubular equipment, code pressure vessels, fabricated plate work, water pipe and allied lines.

Mr. Patton graduated from Cornell with the degree of Mechanical Engineer in 1918. For the following eight years he was connected with

(Continued on page 12)



Tegul-MINERALEAD is clean and easy to handle and work. Those 10 lb. ingots don't mind rain or flood. No skilled labor needed. No delays when pot needs replenishing • Initial leakage heals almost at once, facilitating back-filling and tidying up of premises • And joints are permanently tight under any vibration conditions • Tegul-MINERALEAD *has plenty of what you'll find in no other* Bell and Spigot Jointing Compound.

Write The ATLAS MINERAL Products Co. of Penna., Mertztown, Pa.

Tegul- MINERALEAD

Cathodic Protection

The only positive method of preventing rusting, pitting and corrosion in steel water containers.

THE PATENTED

RUSTA-RESTOR TRADE MARK REGISTERED

PATENTED & PATS. PEND.

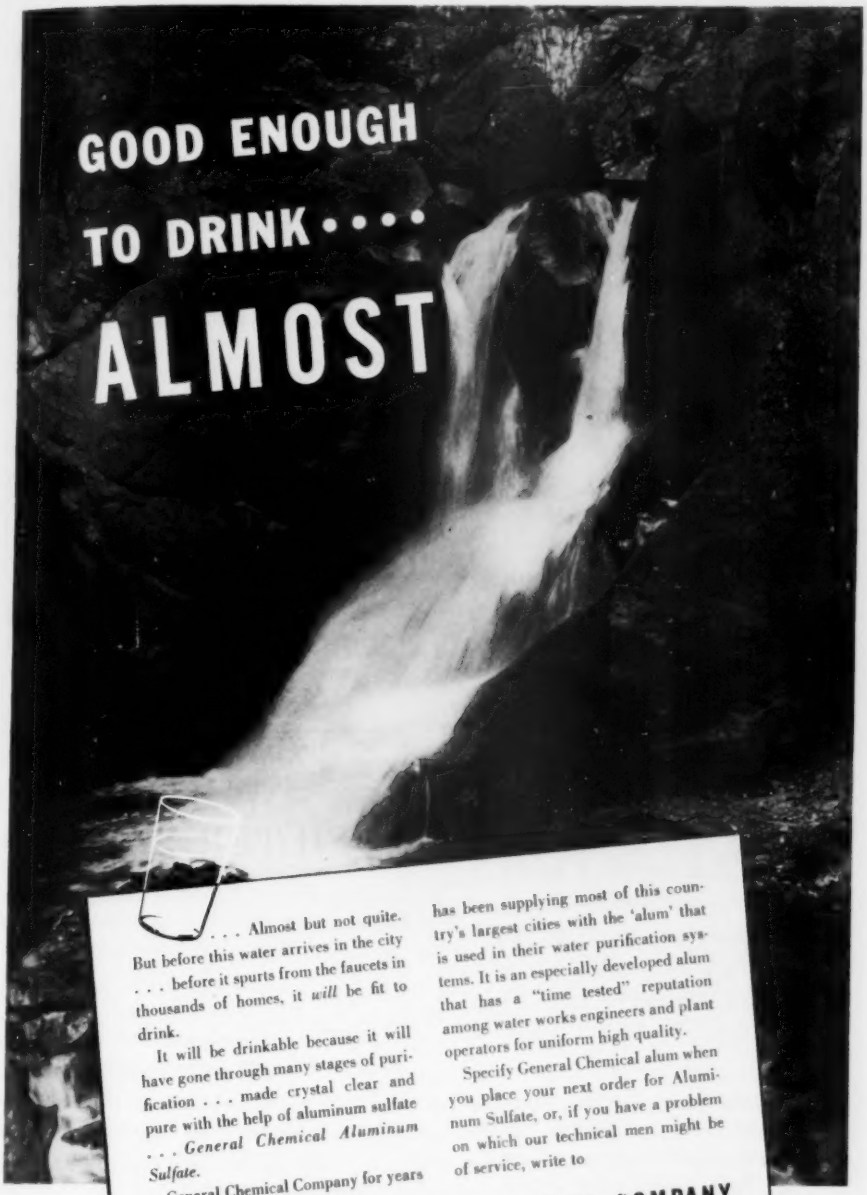
METHOD

Steel Water Tanks
Filter Beds

For complete details write

RUSTA RESTOR CORPORATION

1440 W. State St., Fremont, O.



. . . Almost but not quite. But before this water arrives in the city . . . before it spurts from the faucets in thousands of homes, it *will* be fit to drink.

It will be drinkable because it will have gone through many stages of purification . . . made crystal clear and pure with the help of aluminum sulfate . . . *General Chemical Aluminum Sulfate.*

General Chemical Company for years has been supplying most of this country's largest cities with the 'alum' that is used in their water purification systems. It is an especially developed alum that has a "time tested" reputation among water works engineers and plant operators for uniform high quality.

Specify General Chemical alum when you place your next order for Aluminum Sulfate, or, if you have a problem on which our technical men might be of service, write to

GENERAL CHEMICAL COMPANY
Executive Offices: **40 RECTOR STREET, NEW YORK, N.Y.**
Sales Offices: Atlanta · Baltimore · Boston · Buffalo · Charlotte (N. C.) Chicago · Cleveland · Denver · Houston · Kansas City · Los Angeles · Milwaukee Minneapolis · Montezuma (Ga.) · Philadelphia · Pittsburgh · Providence (R. I.) San Francisco · St. Louis · Utica (N. Y.) · Wenatchee (Wash.) · Yakima (Wash.)
In Canada: The Nichols Chemical Company, Limited · Montreal · Toronto · Vancouver

GENERAL CHEMICAL COMPANY **ALUMINUM SULFATE**
A BASIC 'ALUM' CONTAINING NOT LESS THAN 17.0% AVAILABLE Al_2O_3

(*Continued from page 10*)

the shipbuilding industry in various capacities with the Manitowoc Ship Building Company of Wisconsin, the U. S. Shipping Board, and the Staten Island Ship Building Co. In 1926 he accepted the position of New York Manager for the Biggs Boiler Works Co., of Akron, Ohio. In 1929 he took charge of the sales of fabricated plate work for the Heat Transfer Products Co., which position he held after the Heat Transfer Products Co. was acquired by the American Locomotive Company and later expanded into Alco Products Inc. Later he was made Manager of Equipment Sales for the Alco Products Division, which position he has held until his present appointment.

The first district operator's meeting, covering operators in northwestern Indiana, was held at Rochester, Indiana, last June under the able direction of Jack Gordon, Superintendent. At the one-day meeting were representatives from 19 towns, including three mayors, total attendance being 63. Several short papers were read and there was also an inspection trip to an automatic zeolite iron removal and water softening plant.

(*Continued on page 14*)

EDSON
DIAPHRAGM PUMPS

Hand Operated—size 2″, 2½″, 3″, 4″
Power Operated—size 3″ and 4″
Open Discharge or Force Pump
Skid, Truck or Trailer Mounted

Complete Pump Outfits, Genuine Edson Pumps, Suction Hose, Brass Couplings, Bronze Clamps, Red Seal Diaphragms, Brass Strainer or Foot Valve, Hose Spanners, Adapters, Etc. Brass Hydrant Pump.

THE EDSON CORPORATION
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New York: 142 Ashland Pl., Brooklyn

WHITE
FILTER SAND
98% Pure Silica

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Washed, Screened and Dried. No Freight on Moisture—Prompt shipment in Bags or paper lined Box Cars—Write or wire us for information and prices.

DAWES SILICA MINING COMPANY
Silica Mines
THOMASVILLE, GEORGIA

Modern engineering makes it . . .

LIGHT but **STRONG**



Lowering three coupled lengths of 6", Class 150 "Century" Asbestos-Cement Pipe into trench.

The two ingredients of which K & M "Century" Pipe is made—asbestos, and cement—are among the strongest, longest-lived materials known. To take utmost advantage of these qualities, Keasbey & Mattison uses a special manufacturing process that produces asbestos-cement pressure pipe of exceptionally high strength. Each length passes a hydrostatic test of twice its normal working pressure before shipment.

In "Century" Pipe you get not only an unusually strong, durable and long-lasting pipe—you also get permanent relief from the most serious pipe diseases that keep maintenance costs high. No tuberculation. No corrosion. In addition you get "Century" Flexible Couplings which are easy to install and permanently leak-proof.

Isn't this the kind of pipe you have always wished for—the kind that's needed to keep on serving and saving money for generations to come? It is a product of Keasbey & Mattison Company, pioneers in the development of asbestos-cement products.

FREE. Send for new, illustrated catalogue, "Mains without Maintenance." Address Dept. 1017.



KEASBEY & MATTISON

COMPANY, AMBLER, PENNSYLVANIA

(*Continued from page 12*)

New Materials and Gadgets

1. A blueprinter which requires only a 9 by 26 in. area of desk space has been put on the market. It makes prints up to 18 by 24 in. in size and has a timer to assure accurate exposures.

2. A repeat cycle timer designed for use on a. c. current is especially applicable in the water works field to alternate automatically the operation of two pumps in a dual pumping installation. It has a variety of time ranges and a synchronous motor which is a 2.8 watt slow speed, 450 r.p.m., self-starting, reversible type.

3. A belt grinder has been designed to insure greater safety to the operator who has access to only a 4-inch grinding belt, moving parts being inclosed in a protective metal housing.

4. An adjustable speed motor with a range of speed from zero to full motor speed at full load torque is now on the market. The unit consists of an eddy current clutch and a standard a. c. squirrel cage motor.

5. A diaphragm valve has been designed with glass, rubber or lead lining. The valve is ferrous or non-ferrous and the diaphragm is of synthetic composition compounded especially for specific applications.

6. An automatic time switch, consisting of a length of wire, plug-in connectors and a switch which fits on the alarm winder of a standard alarm clock, is now on the market for use in starting almost anything from a radio to a pump at a set time.

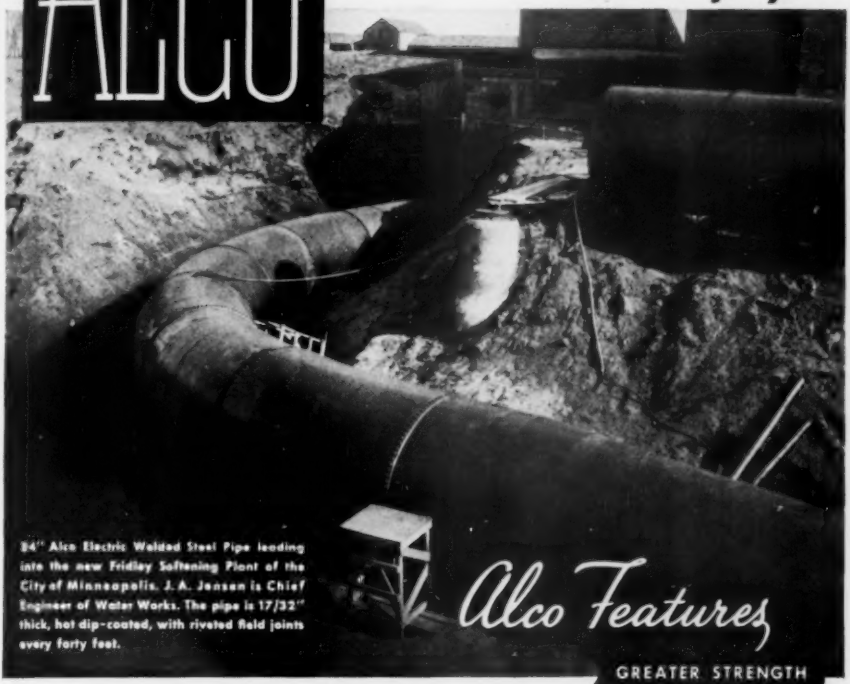
7. Sanding, steel-wooling and polishing of floors are all applications of a new machine which may be used on terrazo or concrete as well as wood and linoleum.

Readers can obtain further information by sending a postal to the A. W. W. A. headquarters giving the reference numbers of any of the above items and citing the November issue as the source.

(*Continued on page 16*)

ALCO

ELECTRIC WELDED *Steel pipe*



84" Alco Electric Welded Steel Pipe leading into the new Fridley Softening Plant of the City of Minneapolis. J. A. Jansen is Chief Engineer of Water Works. The pipe is 17/32" thick, hot dip-coated, with riveted field joints every forty feet.

Alco Features

GREATER STRENGTH
LONGER LIFE
SMOOTHER WATERWAY
LONGER LENGTHS
FEWER FIELD JOINTS
LOW INITIAL COST
ULTIMATE ECONOMY

• Since 1897 Minneapolis has been using steel pipe and now has more than 200,000 feet of it over 30" in diameter in water works and sewage service. All this pipe is in excellent condition. The maintenance cost during 41 years of service has been practically nil—no breaks, no shutdowns for repairs.

Why not be guided by the experience of this progressive city?

ALCO PRODUCTS

DIVISION OF

AMERICAN LOCOMOTIVE COMPANY
THIRTY CHURCH STREET NEW YORK, N. Y.

AMERICAN LOCOMOTIVE SALES CORP.
(INCORPORATED IN U.S.A. WITH LIMITED LIABILITY)
ARTILLERY HOUSE, ARTILLERY ROW, LONDON, S. W. 1, ENGLAND

(*Continued from page 14*)

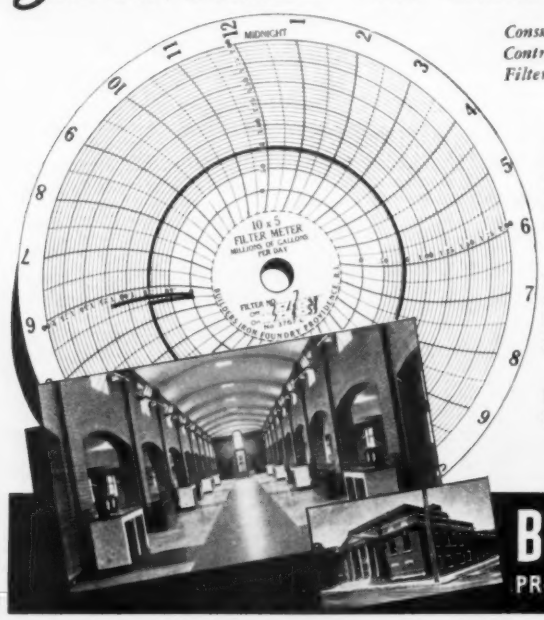
George N. Schoonmaker, Chief Engineer of the Toledo, Ohio, Water Department and formerly Director of Public Service for Toledo, has been made City Manager. He was selected from a field of 13 candidates and succeeds John N. Edy who has been appointed Administrative Assistant to John M. Carmody, Federal Works Administrator, to act as budget director of the F.W.A.

Geology and Ground-Water Hydrology of the Mokelumne Area, California is the title of Water-Supply Paper 780 of the Geological Survey, U. S. Department of the Interior. The paper is by A. M. Piper, H. S. Gale, H. E. Thomas, and T. W. Robinson. It has 230 pp., 22 plates and 28 figures, and is priced at $2.25. It is described in part as follows in the Geological Survey Publications List 379:

"The Mokelumne area, about the city of Lodi in central California, is a fertile plain that has been intensively developed for the cultivation of grapes, deciduous fruits, and other crops. Of necessity its great productiveness is maintained by irrigation. Extensive irrigation from wells

(*Continued on page 18*)

Smooth Control AT LAWRENCE, MASS.



Consulting Engineers, Metcalf & Eddy
Contractor, James A. Munroe & Sons
Filter Equipment, Norwood Engr. Co.

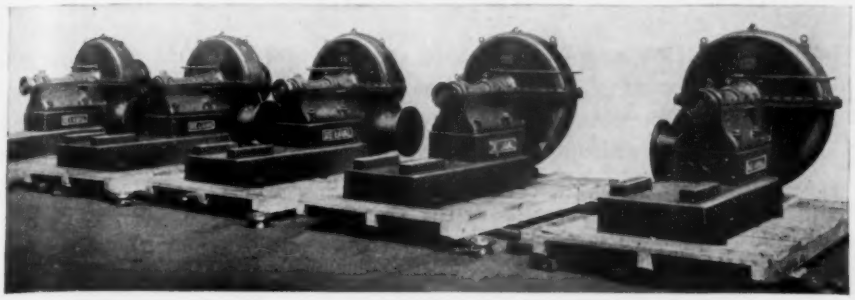
Another fine filtration plant has been placed in operation with eight Venturi Direct-Acting Controllers on the job. The chart from one of the Builders Rate-of-Flow Gauges shows the smoothness of filter effluent control.

This day after day performance of these controllers is typical; it is one reason why Builders Controllers have been selected for so many filtration plants, both large and small.

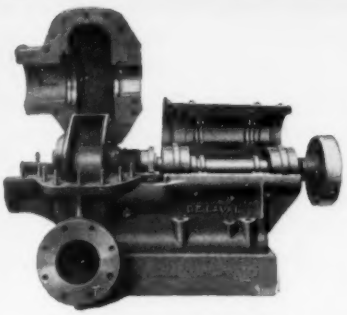
The same satisfaction is yours if you insist on Builders Water Works Equipment.

Have you a copy of Bulletin 297?

BUILDERS IRON FOUNDRY
PROVIDENCE, RHODE ISLAND



Five of an order of seven Clogless Pumps; six rated at 10,400 g. p. m. against 15 ft. and one at 7000 g. p. m. against 27 ft.



Clogless pump with casing cover and bearing cover lifted.

DE LAVAL
CLOGLESS PUMPS
for liquids carrying solids have the following distinctive features:

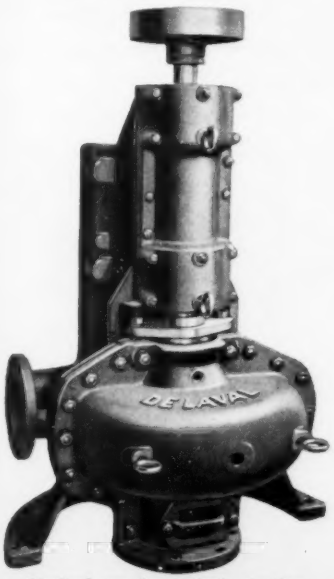
IMPELLER: Shrouded or enclosed; single suction; wide passages; extra long hub protected by renewable bronze sleeve.

WEARING RINGS: Of bronze, one threaded on impeller and other seated in casing and cover; arranged for clear water sealing.

STUFFING BOX: Located over impeller hub to reduce shaft overhang, clear water sealed; gland horizontally split.

BEARINGS: Spaced well apart to give steady support to shaft; instantly accessible upon lifting bearing cap; large duplex ball thrust bearing; grease lubricated.

CASING: Split horizontally; cover removable without disconnecting piping; pump overhangs bedplate so that piping connections are accessible; hand-hole cover for quick inspection.



Clogless pump for vertical mounting.

● **Ask for Catalog B-1** 3304

DE LAVAL *Steam Turbine Co.*
TRENTON, N. J.
MANUFACTURERS OF STEAM TURBINES, PUMPS—CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, CENTRIFUGAL BLOWERS AND COMPRESSORS, WORM GEARS, HELICAL GEARS, HYDRAULIC TURBINES AND FLEXIBLE COUPLINGS • • • SOLE LICENSEE OF THE BAUER WACH EXHAUST TURBINE SYSTEM

(Continued from page 16)

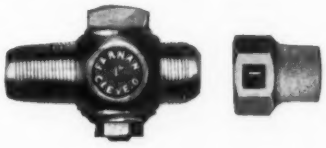
began about 1907 and has increased steadily, until in 1932 about 50,000 acres (80 per cent of the area) was so watered. The yearly pumpage from wells has been as much as 114,600 acre-feet (1928–29), and as many as 2,500 wells have been equipped with irrigation pumping plants. This report is concerned with the extent to which the supply of ground water, and hence the productiveness of the area, are dependent upon the water flowing in the Mokelumne River and the extent to which the supply of ground water may be influenced by regulation of the river—in particular, by the substantial regulation that is accomplished by the Pardee Dam of the East Bay Municipal Utility District, which began to function in March, 1929. With respect to ground-water replenishment by seepage loss from the river, it is concluded that (1) the yearly replenishment has tended to increase for at least two decades, owing to gradually prolonged use of the Woodbridge Reservoir and to the gradual increase in head between surface water and ground water as ground-water levels have been lowered progressively by pumping, and (2) the rate of replenishment tends to be greater under regulation than under the so-called natural regimen, to

(Continued on page 20)

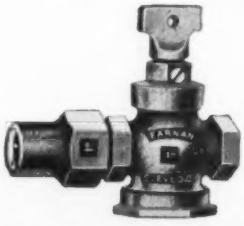
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Established in the Water Works Field since 1852.

Continued acceptance throughout 87 years of satisfactorily meeting Water Works requirements is your Proof.



FARNAN Quality and Durability



All our products are accurately machined to gauges and Tested at 200 lbs. Hydrostatic Pressure.

THE FARNAN BRASS WORKS CO.
CLEVELAND *EST. 1852* OHIO

WATER-BORNE
OUTBREAKS
in the
UNITED STATES
and
CANADA

1920–1936

by
Arthur E. Gorman
and
Abel Wolman

An unparalleled summary of studies concerning the relation of water supplies to typhoid fever, gastro-enteritis, etc.

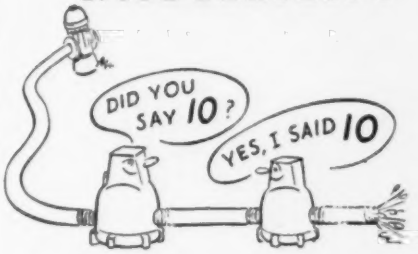
A brochure that should be in the library of every sanitary engineer.

Price $1.25—postpaid if cash or check accompanies the order.

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AMERICAN
WATER WORKS
ASSOCIATION

22 East 40th St.
New York, N. Y.

We **ARE** *interested!*



WE *did* receive the following letter from a superintendent of a water department.

"You may be interested in the following test of a 6-inch Empire Meter No. 905906 set June 25, 1912.

The test was made with a 50-foot length of hose in our yard from a hydrant with 88 lbs. pressure, running the water also through a new 2-inch Empire first.

Size of Stream	*6-inch Empire No. 905906 Registered*	*New 2-inch Empire Registered*
1/8 in.	10 ft.	10.6 ft.
1/4 in.	10 ft.	10.2 ft.
3/8 in.	10 ft.	10 ft.
1/2 in.	10 ft.	10 ft.
3/4 in.	10 ft.	10 ft.
1 in.	10 ft.	10 ft.
1 1/4 in.	10 ft.	10 ft.
1 1/2 in.	10 ft.	10 ft.
2 in.	10 ft.	10 ft.

The meter was not cleaned before testing and reading to date is 76,543,600 cu. ft. I think that you are to be congratulated on a test like this."

We will be glad to show this letter to you.

NATIONAL METER COMPANY
4207 First Avenue, Brooklyn, N. Y.
BOSTON • CHICAGO • DALLAS
LOS ANGELES • SAN FRANCISCO • SEATTLE

NATIONAL *Meters*

(*Continued from page 18*)

the extent that regulation has maintained a moderately large wetted area and stage in the river through the later part of each pumping season, when the ground-water levels have been lowest. . . ."

A revised edition of *The Bacteriological Examination of Water Supplies* (Report no. 71) which was reviewed by M. H. McCrady in the July, 1939 Journal, can be obtained through the British Library of Information, 50 Rockefeller Plaza, New York City. Thirty cents in coin or money order should be sent for each copy desired. Prospective purchasers are cautioned that it may take at least six weeks to obtain the document.

R. F. Goudey, Sanitary Engineer, Bureau of Water Works and Supply, Los Angeles, who entered the Gadget Contest at the California Section Meeting at San Francisco with an ultra violet ray recorder, sends the following report:

"The common conception that algae growths in reservoirs are increased with temperature is disproven by the new ultra violet ray meter as used by the Bureau of Water Works and Supply of Los Angeles. The

(*Continued on page 22*)

DIFCO

Liquid Confirmatory Media for Coli

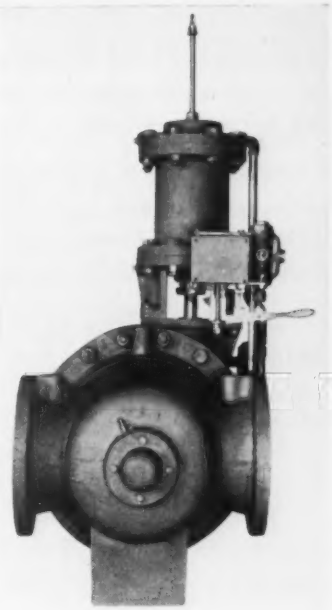
This group of Dehydrated Culture Media, Difco is recommended for use in confirming the positive presumptive test for coliform bacteria in water. When prepared for use each of these media meets the requirements of the official formula as specified in "Standard Methods of Water Analysis" (8th Edition) of the American Public Health Association

Bacto-Brilliant Green Bile 2%
Bacto-Crystal Violet Lactose Broth
Bacto-Formate Ricinoleate Broth
Bacto-Fuchsin Lactose Broth

Specify "DIFCO"
THE TRADE NAME OF THE PIONEERS
In the Research and Development of Bacto-Peptone and Dehydrated Culture Media

DIFCO LABORATORIES
INCORPORATED
DETROIT, MICHIGAN

RENSSELAER ENTERS THE CONE-VALVE FIELD



Rensselaer Cone-Valves are equipped with a Patented HYDRAULIC OPERATING DEVICE, which is Simple, Positive, and Efficient

They are the *Ideal* Valves where *Positive Control* is required and are suitable for use as:

- ALTITUDE CONTROL VALVES
- PRESSURE CONTROL VALVES
- AUTOMATIC CHECK VALVES
- PRESSURE RELIEF VALVES
- FREE DISCHARGE VALVES
- LINE VALVES where quick and easy valve closure is essential

FOR FULL INFORMATION ADDRESS

RENSSELAER VALVE CO.

TROY, NEW YORK

(*Continued from page 20*)

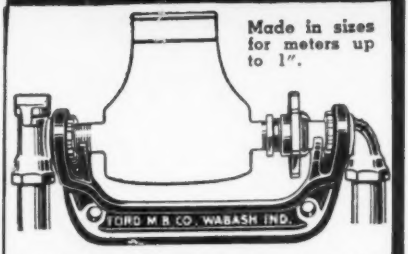
data averaged from thirteen reservoirs show that ultra violet radiation has more of an influence on algal growths than does temperature. In fact, hot weather tends to discourage algal growths around Los Angeles."

"**Ozone and Palatability**" is the title of a bulletin recently published by Ozone Processes, Inc., 1500 Walnut St., Philadelphia. A brief résumé of the scientific development of ozone is followed by detailed description of water purification by ozonation, along with illustrations and diagrams.

Piping Handbook by J. H. Walker and Sabin Crocker has now been published in its third edition by McGraw Hill Book Company, Inc., New York. The authors are members of the technical staff of The Detroit Edison Company and are well known in the mechanical engineering field for their various works on power plant, heating and ventilating, expansion of pipes, air conditioning, etc.

The new edition consists of 897 pages and covers piping in all its applications from use in a modern steam plant carrying 850 lb. 900°F. steam to use in the simplest domestic water supply system. The latest

(*Continued on page 26*)

FORD YOKES
FOR RISER SETTINGS . . FOR ANGLE SETTINGS . . FOR LINE SETTING
MAKE EASY METER CHANGES
Made in sizes for meters up to 1".


Ford Yokes connect inlet and outlet service pipes permanently and make easy, trouble-free meter changes. May include an inverted ground-key angle valve at the meter inlet. Made for all types of piping connections. Hundreds of thousands in service. Further information for the asking.
The Ford Meter Box Co.
WABASH, INDIANA


QUALITY
A TRADITION
A fifty year record of proven quality . . . a complete line of Fire Hydrants built to modern requirements and meeting the specifications of the A.W.W.A. Send for descriptive sheets.
JOHN C. KUPFERLE FOUNDRY CO.
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Engineers
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(*Continued from page 22*)

edition has up-to-date information on materials and methods of manufacture used to meet increases in pressure and temperature. The subject of welding has been developed with treatment of valves and fittings designed for direct welding in the line. An entire chapter is devoted to the metallurgy of piping materials and A. S. T. M. specifications are given in abstract. Formulas, diagrams and tables are well arranged for easy solutions of problems of friction, pressure, drop, discharge of pipes, nozzles, etc. Price of the book is $5.00.

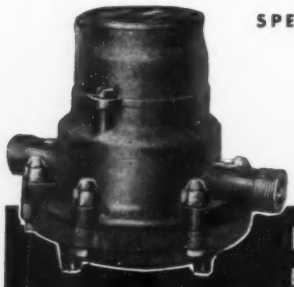
"**Doctor Jones**" in a recent issue of *Health News*, publication of the New York State Department of Health, says:

"There was a fellow down here awhile ago from Albany—was telling about the big celebration they had up in Buffalo over the opening of their new sewage disposal plant up there. Of course you have to be a sanitary engineer to get real sentimental about sewage (I heard of one of 'em: got all het up because his wife wouldn't let him hang a picture of a disposal plant in the parlor 'longside his mother-in-law's portrait). But, anyway, Buffalo'd been discharging sewage into the Niagara river for years and hadn't done anything about it, I suppose on account of the cost. It does run into considerable money. Now they're as proud of their plant as a boy with his first pair of long pants and they've got a right to be: it's one of the finest in the country, so they say.

"I remember reading about what happened back in the spring of thirty-three—I think it was. It seems an ice jam went out of the river all of a sudden and let loose an accumulated 'slug' of sewage (that's what the engineers call it) and down below there, in Niagara Falls, they got their

(*Continued on page 29*)

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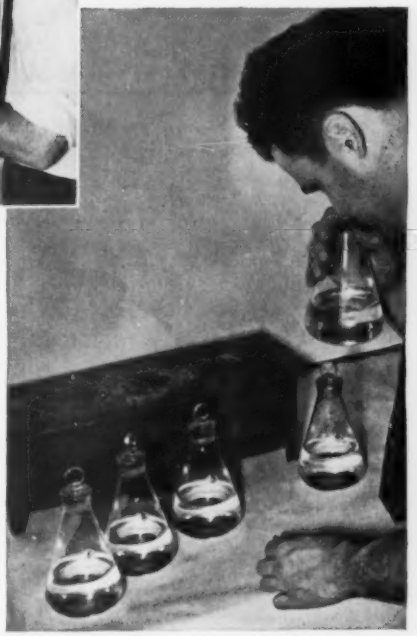




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A reciprocal relation, the life and functioning of the one depending much on the other.
A. D. COOK, INC.
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COOK Deep-Well Turbine Pumps

(*Continued from page viii*)

Affiliates

HARVEY, J. R. Asst. Engr., Pa. Dept. of Health, 609 Trust Bldg., Meadville, Pa.
VICKREY, JOHN A. Operator in the Filtration and Treatment Plant, 1118 West Los Olos Blvd., Fort Lauderdale, Fla.
WRIGHT, CLARENCE W. Asst. Civil Engr., Detroit Dept. of Water Supply, 15492 Woodingham Dr., Detroit, Mich.

Reinstatements (Active)

COREY, R. H. Cons. Engr., 909 Bedell Bldg., Portland, Ore.
MURDOCH, WILLIAM J. San. Engr., 1123 Cornell St., Pittsburgh, Pa.
THOMAS, EDGAR. Supt. of Water Works, Box 205, Yreka, Calif.

Deaths

DIEHL, PAUL A. Chemist, 4706 Broadway, Kansas City, Mo.
FEIST, MARTIN. Supt., Machinery Equipment, Water Works, Dayton's Bluff, Station B. 4, St. Paul, Minn.
HAYT, ROBERT O. Cons. Engr., P. O. Box 117, Corning, N. Y.
LEONARD, CHARLES A. Supt. of Public Works, Hoosick Falls, N. Y.
MERRIMAN, THADDEUS. Cons. Engr., 611 W. 110th St., New York, N. Y.

Transfers between Sections

BURNS, ROSS J. From Ohio to Illinois.
COATES, JOHN JAMES. From New York to Four States.
MATHEWS, W. W. From Wisconsin to Indiana.
STANLEY, WM. E. From Illinois to New York.
STARLING, CHARLES H. From Southeastern to North Carolina.
STRAETZ, A. G. From Illinois to Indiana.

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also manufacturers of the well known INVERSAND water softener

(*Continued from page 26*)

drinking water out of the river,—they had something like 10,000 cases of gastroenteritis—stomach and bowel trouble, that is. Of course they were chlorinating the water but they weren't prepared for a deluge. Why, they claim they even saw the effects of it way up in the St. Lawrence river, three hundred miles away.

"You know this question of treating sewage—it's some like building a new school in a small town: there's most always an argument about it. Makes me think of the row we had over across the track here years ago. Some folks by the name of Mooney and a—I forget the name of the other family—they lived next to each other. The other fellow had a cesspool—overflowed on to Mooney's back yard and wouldn't do anything about it. Then Mrs. Mooney started emptying her slop pail over the fence and the fight was on. Like the story in my old third reader: 'It makes a difference whose ox is gored.' Well—both of 'em finally agreed to keep their slops at home and things quieted down.

"When you get right down to it, there ain't an awful lot of difference, whether it's a family or a municipality. All a city or village is—it's just a collection of individuals that've parked 'emselves in the same locality. It may be an awful lot of trouble and expense to take care of their sewage but it ain't any more polite for 'em to run it over onto the other fellow than it was for Mrs. Mooney to empty her pail over the fence. And they say treating the sewage ain't going to lower Niagara Falls any. The water'll be there, only it'll be clean."

Lock Joint Pipe Co., Ampere, N. J., recently issued a leaflet describing carrying capacity tests conducted at Denver, Colorado. Illustrations and tabulated statistics are given.

The village of Wolcott is one of a decreasing number of municipalities in New York state which has continued to experience almost annually a shortage of water during summer months. On September 8, the public

(*Continued on page 30*)

(*Continued from page 29*)

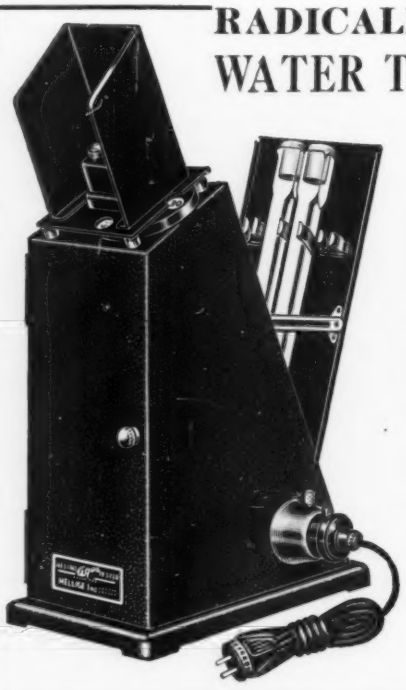
water supply of the village became practically exhausted and arrangements were made to pump water from a surface stream with a local fire engine. A temporary installation was made for the treatment of the water with hypochlorite of lime in order to make it bacterially safe. On September 9 the village started the drilling of a well which had progressed sufficiently by September 13 to permit its use on that date. The fire engine was put back in the firehouse and the village officials have determined to follow through to a permanent solution of the problem before another summer.

Notice Regarding Changes in Patent Laws and Practice

The following résumé was submitted to the Association by Sheppard T. Powell, Chemical Engineer, Baltimore, Md., and was prepared by Green & McCallister, Grant Bldg., Pittsburgh, Pa.

Public Use Period Reduced to One Year. Effective August 5, 1940, the two-year period heretofore permitted for public use of an invention within which a patent application could be filed and a valid patent ob-

(*Continued on page 32*)



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WATER TEST COMPARATOR

The new Hellige Aqua Tester combines the thoroughly demonstrated advantages of Hellige *non-fading glass color standards* with radical improvements in design. This new model is, we believe, the most advanced type ever brought on the market and demands special consideration as it brings to its user the utmost in permanent reliability, accuracy, convenience and, last but not least, economy. Standards for all popular A. P. H. A. and A. W. W. A. Methods and Hydrogen Ion Control are available.

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(*Continued from page 30*)

tained, has been reduced to one year. This does not apply to applications filed prior to August 5, 1940, nor does it affect patents resulting from such applications.

Interference Appeals Abolished. Effective October 5, 1939, interference proceedings will be determined by a Board of three Interference Examiners, appeal from which shall be to the Court of Customs and Patent Appeals or to the District Court for the District of Columbia. This means that only one decision in interference proceedings will be rendered in the Patent Office. The above does not apply to interferences pending on or before October 5, 1939.

Copying Claims from Issued Patents for Purposes of Interference. The law which permits an applicant for a patent to copy claims from an issued patent, for the purposes of interference, has been changed so that no such claim may be copied from the patent more than a year after the issuance thereof unless the substantial subject matter of the claim was asserted as a part of the applicant's invention prior to the termination of such year.

Time for Response to Official Actions. The Statute under which an applicant has six months in which to respond to an official action by the

(*Continued on page 34*)

American Water Works Association
60th Annual Convention
Kansas City, Mo., April 21-25, 1940

Scheduled Hotel Rates

Rooms	Phillips	President	Muehlebach
Single Bedroom	$2.50- 5.00	$2.50- 5.00	$3.50- 6.00
Double Bedroom, 2 persons	4.00- 8.00	4.00- 6.50	5.00- 8.00
Twin Bedrooms, 2 persons	6.00- 8.00	5.00- 8.00	6.00-10.00
Suites			
Parlor and 1 Bedroom	12.00-15.00	15.00	15.00-25.00
Parlor and 2 Bedrooms		20.00	21.00
Parlor, Dining Room and 2 Bedroom			35.00
Parlor and 3 Connecting Bedrooms	25.00		
Parlor and 4 Connecting Bedrooms	35.00-40.00		

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IN SERVICE OR UNDER CONSTRUCTION BY OCTOBER, 1939

● Users in ever increasing numbers are demonstrating that the Accelator is the ideal process for water softening, clarifying and stabilizing. In April 1938 there were 28 Accelators in service or under construction. By October there were 41, and by October 1939 there were 82.

● This rapid acceptance is significant. It indicates the widespread satisfaction with Accelator plants in actual service—satisfaction based not upon claims, but rather upon *realities and performance records.*

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(*Continued from page 32*)

Patent Office has been amended so that in any particular case the Patent Office may reduce the time to a period of not less than a month by giving applicant written notice of the reduction. The amended Statute seems to us to be somewhat ambiguous but we interpret it as meaning that where the Patent Office reduced the time for response the applicant may have the time extended, but not beyond the six months period, by satisfying the Commissioner of his inability to answer within the fixed time. The amendment to the Statute was approved August 7, 1939 and became effective as of that date.

Renewal Applications Abolished. Approved August 9, 1939 and now in effect is a provision for abolishing renewals. In any case in which the notice of allowance was mailed by the Patent Office prior to August 9, 1939, the old practice will remain in effect. Under the new practice, if the final fee is not paid within the allotted six months period, the patent shall be withheld, but nevertheless the Commissioner may in his discretion receive the final fee if the same is paid within one year from the expiration of the six months period, provided, however, that to take advantage of this it will be necessary to file a petition accompanied by a fee of $10.00

(*Continued on page 36*)

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One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

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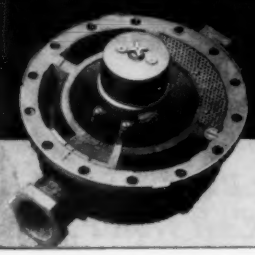


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(Continued from page 34)

requesting acceptance of delayed payment of the final fee. It will be noted that it may now be possible to obtain a maximum delay of approximately eighteen months from the issuance of the notice of allowance and that after the passage of the eighteen months period the application will become abandoned subject to the possibility of revival under the existing provisions for the reviving of an abandoned application.

Prints and Labels to be Handled by Copyright Office. On and after July 1, 1940 the Register of Copyrights will have charge of all applications for registration of prints and labels, and the fee will continue to be $6.00. Print and label applications pending in the U. S. Patent Office and not consummated at the close of business June 30, 1940 will be dropped and all fees returned to the applicants. The presumption is that the same can and must be refiled in the Copyright Office.

As the JOURNAL goes to press:

The deaths on November 15 of **Willard C. Lawrence,** Acting Commissioner of Water and Heat, Cleveland, Ohio, and of **M. H. Collins,** Sales Manager, Louisville Branch, Rensselaer Valve Co., Louisville, Ky., are reported.

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NEWS OF THE FIELD

Do you use A. W. W. A. Specifications? Then this will interest you. The results of three major standardization activities of the A. W. W. A. will be made available to the membership within the next few weeks.

The Committee on "Specifications for Cast Iron Pipe" through its Chairman, Thomas H. Wiggin, has submitted its report to the four sponsor societies, banded together for this work under American Standards Association control. These organizations, The American Gas Association, The American Society for Testing Materials, The New England Water Works Association and The American Water Works Association, have approved the report. It was submitted to the A. S. A. Council and given final approval on December 5, 1939. Thereupon the complete text appears as a section of this Journal.

Under the dynamic leadership of W. V. Weir of the St. Louis County Water Co., an association committee on "Distribution System Records" has brought to completion a fine manual of recommended practice. The report is now in circulation among the members of the Board of Directors and the Water Works Practice Committee. If the Committee approves, the report will be formally considered by the Board in its January, 1940, meeting. Thereafter the material may be expected to issue in the JOURNAL.

Former A. W. W. A. President Hurlbut of Los Angeles is bringing to a tentative close a magnificent job of association committee activity. A series of *tentative* specifications for steel pipe, tar enamel coatings and linings, and cement mortar coatings and linings has been ordered published in the JOURNAL when the Committee approves the text. This approval is imminent and the probabilities are that the January issue of the JOURNAL will bring this material to the attention of all members.

Here are three major projects nearing completion. This Association has cooperated with other associations in developing the first. Through its own membership it has brought the second to completion. The third, under association control, has had the cooperative support and advice of the producing industry. The reports represent real milestones in A. W. W. A. progress.

But Mr. Member—their real value lies in your use of them when they are done. Think that over!

(*Continued on page 2*)

(*Continued from page 1*)

W. H. Hall, formerly Professor of Civil Engineering and Chairman of the Division of Engineering, Duke University, has been appointed Dean of Engineering. He holds this title in the College of Engineering recently created by the Board of Trustees of Duke University. Engineering at Duke was formerly administered as a part of Trinity College. Three curricula in engineering will be offered, civil, electrical and mechanical. The enrollment is now 216 and the maximum has been set at 225. The civil and electrical departments will have full time teaching staffs of four men each and the mechanical division will have five men. Prof. Hall has been a member of the A. W. W. A. since 1930.

Flash—**W. C. Hawley,** Vice-President and Superintendent of the Pennsylvania Water Company, Wilkinsburg, Pa., died at his home on December 10, 1939. He was born 74 years ago in Cambridge, N. Y., and was a graduate of Rensselaer Polytechnic Institute. After construction experience in Pittsburgh with the firm of Wilkins and Davison, he was Superintendent of the water department at Atlantic City before becoming associated with the Pennsylvania Water Company in 1902. Mr. Hawley was a member of Committee A21 on Specifications for Cast Iron Pit Cast Pipe. He had been a member of the Association since 1910.

(*Continued on page 4*)

C. Arthur Brown, a leader in water purification for many years, died at the age of 73 on November 4 at Lorain, Ohio. Mr. Brown was born in Gallipolis, Ohio; attended Chaddock College in Quincy, Ill., where he first became interested in water purification through work in the Quincy water works. He came to Lorain in 1896 as an engineer with the O. H. Jewell Filter Co. and designed and supervised construction of the Lorain Municipal Water Works, a plant which had many unique features when it was built. He promoted the use of ferrous sulfate (copperas) in water plants throughout the country. He served on George W. Fuller's staff at Louisville during the experimental studies leading to the "1895 Report."

In 1905 he became Chief Engineer for the American Steel & Wire Co. in its water purification bureau, holding this position until his retirement six years ago. About twelve years ago he invented the equal pressure diaphragm, a device to measure accurately the amount of water pumped into a filtration plant from the source of supply.

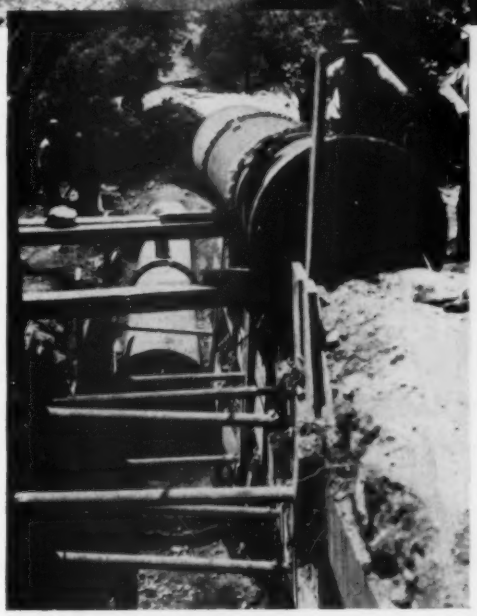
Mr. Brown was a member of the A. W. W. A. since 1905.

THEY RELAID IT—WOULDN'T YOU?



Highway improvements necessitated relocating a 36-inch, 46-year-old cast iron water main at Fort Worth, Texas. This pipe is shown above after being removed from the old trench.

At right is a photograph of the old pipe being relaid in a new location after 46 years of continuous service.



Salvage value is one of the three major economies of cast iron pipe. Long life and low maintenance cost complete the thrift story of this standard material for underground mains, known as Public Tax Saver No. 1.

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Cast iron pipe is made in diameters from 1¼ to 84 inches.
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CAST IRON PIPE
PUBLIC TAX SAVER NO. 1

(*Continued from page 2*)

Ben S. Morrow, formerly Chief Engineer and General Manager of the Portland, Oregon, water bureau, has been promoted to the office of City Engineer. Mr. Morrow served as Chief Engineer of the water Bureau since 1925. After being graduated from Stanford University and a year of private work, he entered city service in 1910 as a draftsman on designs for Mount Tabor reservoirs.

J. C. Perlas, who made an extensive trip and study of water plants in the United States and studied for a time at Massachusetts Institute of Technology during the past year, is now back in Manila, P. I. After leaving the United States he made a tour of water plants in several European countries. Mr. Perlas, who is Assistant Superintendent of Filtration for the Metropolitan Water District, Manila, writes from Manila early in October as follows:

"My trip on the Continent, though made quite hastily, was nevertheless pleasant and interesting. It gave me an opportunity to compare the things I saw in America with those in Europe. My impression is that the United States is the more progressive in water treatment in that more time

(*Continued on page 6*)

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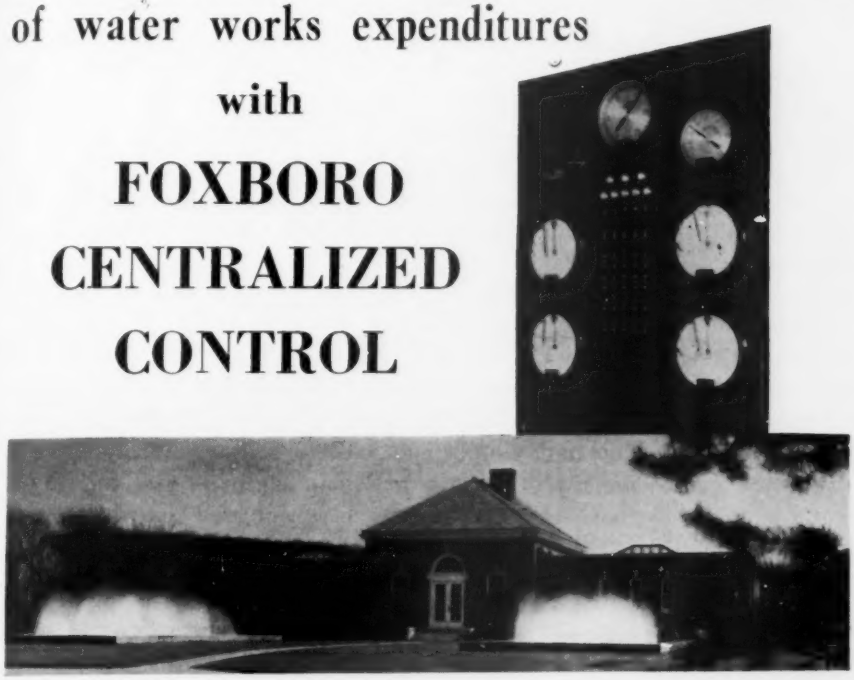
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When funds must be provided for a new plant, or for modernization or extension, public understanding and approval must be won. At such a time no argument is more convincing than a Foxboro Instrument Board for Centralized Control. It silently, but convincingly, tells the story of efficient dependable operation. In a plant engineered for Foxboro Centralized Control, the instruments which so capably protect the community's supply of pure water are attractively displayed in a business-like control room. This permits close inspection by visitors yet keeps the controls safe from tampering. Such an arrangement makes the plant operation and expenditures easily understood by the taxpayer. • • • Foxboro's Centralized Control not only looks business-like, but makes possible appreciable savings in construction and piping layouts. Write for full information and a copy of the new Bulletin No. 233 "Foxboro Instruments for Filtration and Water Treatment Plants."

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REG. U. S. PAT. OFF.

RECORDING · CONTROLLING · INDICATING
Instruments
TEMPERATURE · LIQUID LEVEL
PRESSURE · FLOW · HUMIDITY

Certified ACCURACY and RESPONSE

The FOXBORO COMPANY
150 Neponset Ave., Foxboro, Mass., U. S. A.

Branch Offices in 25 Principal Cities

(*Continued from page 4*)

and effort are being devoted in the United States to study and research on the subject. It seems too that the authorities in Europe have the tendency to adopt the most economical process of treatment consistent with good results, while in the United States the safest and most satisfactory method is usually adopted irrespective of costs."

The Louisiana Engineering Society will hold its forthcoming annual meeting on January 12 and 13, 1940, at the St. Charles Hotel in New Orleans.

The old oaken bucket now hangs in the office of W. W. Hurlbut, Assistant Chief Engineer and General Manager of the Bureau of Water Supply of Los Angeles. It hangs by a rusty chain in Bill Hurlbut's office because the California Section had the largest roster of any Section of the Association on the opening day of the Atlantic City Convention. Between the encroachments of the tin pail manufacturers and municipal water supplies, old oaken buckets have become things of the past and of song. It took Roger Esty many a day of tortuous touring of New England

(*Continued on page 8*)

EDSON
DIAPHRAGM PUMPS

Hand Operated—size 2", 2½", 3", 4"
Power Operated—size 3" and 4"
Open Discharge or Force Pump
Skid, Truck or Trailer Mounted

Complete Pump Outfits, Genuine Edson Pumps, Suction Hose, Brass Couplings, Bronze Clamps, Red Seal Diaphragms, Brass Strainer or Foot Valve, Hose Spanners, Adapters, Etc. Brass Hydrant Pump.

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Main Office and Works: 49 D St., South Boston, Mass.
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WHITE
FILTER SAND
98% Pure Silica

Washed, Screened and Dried. No Freight on Moisture—Prompt shipment in Bags or paper lined Box Cars—Write or wire us for information and prices.

DAWES SILICA MINING COMPANY
Silica Mines
THOMASVILLE, GEORGIA

You're the doctor



WHO CAN CURE SUCH COSTLY PIPE DISEASES AS TUBERCULATION

Tuberculation costs many a water works thousands of dollars a year. So do pipe corrosion and electrolysis . . . all the familiar troubles that keep maintenance crews busy. Most of them are unnecessary! Asbestos-Cement pressure pipe puts an end to them, saving not only on maintenance, but on pipe replacements and pumping costs as well.

Now, The Keasbey & Mattison Company, the pioneers in asbestos development, bring you "Century" Asbestos-Cement Pressure Pipe . . . a superior product of high, uniform strength, made by a new and improved process. A pipe that provides exceptionally long service life. A pipe easily handled and laid because of its light weight. Non-tuberculating, non-corrosive, never attacked by electrolysis. Each length is subjected to a hydrostatic test of twice its normal working pressure.

FREE — Complete, illustrated catalogue on "Century" Asbestos-Cement Pressure Pipe. Covers every phase of the subject, answering all your questions in detail. This book may help to save you thousands of dollars in pipe maintenance, in replacements, and in pumping cost. Mail the coupon today for new catalogue, "Mains without Maintenance."



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Send me, without obligation, free catalogue on "Century" Asbestos-Cement Pressure Pipe — "Mains without Maintenance."

NAME _____

NAME OF PLANT _____

ADDRESS _____ JAWWA-2

(*Continued from page 6*)

to find this one which Bill Hurlbut now so carefully preserves. It has a copper plate on it which shows the California Section the winner in 1939.

The 1940 Census will assemble many statistics of basic importance to the water works field, although no actual census of municipal water supply sources will be made. Under the Census of Manufactures opening in January, there will be assembled statistics on the production of all kinds of equipment used in the water supply field.

Under the Census of Housing, to be taken in connection with the Census of Population in April, approximately 33 million dwelling units of the country will be enumerated. As each of these dwelling units is enumerated, representatives of the Census Bureau will ascertain information on water supply. Occupants will be asked whether there is (1) running water within the dwelling unit, (2) hand pump within the dwelling unit, (3) running water outside dwelling unit (piped), (4) other outside water supply *within fifty feet* of dwelling unit, or (5) other outside water supply *fifty feet or more from* dwelling unit.

(*Continued on page 10*)

STORE IT in THE OPEN

Until you're Ready to Use it

NO roof or tarpaulin is needed to guard Tegul-MINERALEAD against storm or flood • The ingot ISN'T HURT BY WATER • These 10 lb. blocks are EASILY HANDLED and shipped • COMPOSITION CAN'T CHANGE under jolting in transit • Tegul-MINERALEAD makes PERMANENTLY TIGHT, trouble-free joints, amply able to withstand any vibration • JOINTS HEAL ALMOST AT ONCE. Trenches can be back-filled and traffic hazards cleared up • Send for more information. The ATLAS MINERAL PRODUCTS Company of Pa. Mertztown, Pennsylvania.

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MINERALEAD

RUSTOP *the* Cathodic Method of Eliminating and Preventing Rust and Corrosion in Steel Water Tanks.

Eliminates the Necessity of Painting below the Overflow.

Now Used by Many Cities And Manufacturers. Write For List Today.

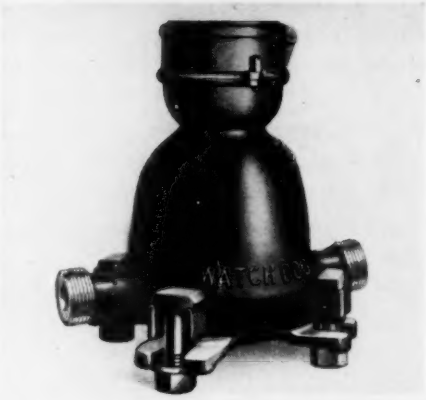
Cleans Old Tanks. Keeps New Tanks Clean. (Pat. Pend.)

ELECTRO RUST-PROOFING Company

Third National Building

Dayton, Ohio

WATCH DOG METERS





Frost-proof meter



Turbine meter

Investigate these meters

WHEN looking over your requirements, remember that thousands of municipalities are getting satisfactory low-cost service from Worthington-Gamon Meters.

WORTHINGTON-GAMON METER COMPANY

General Offices: HARRISON, NEW JERSEY

Offices and Representatives in Principal Cities

WORTHINGTON-GAMON

WG9-4

(*Continued from page 8*)

Census takers will ascertain what the toilet facilities are with regard to (1) flush toilet within structure for *exclusive use* of the household, (2) flush toilet within structure *shared* with other households, (3) chemical or other non-flush toilet within structure, (4) outside toilet or privy, or (5) no toilet or privy.

With regard to bathroom facilities, representatives of the Census Bureau will ascertain whether the dwelling unit is equipped with (1) bath tub or shower with running water within structure for *exclusive use* of the household, (2) bath tub or shower within structure *shared* with other households, or (3) no bath tub or shower within structure.

The Census of Housing will be the first undertaking of the federal government in this field on a nationwide scale.

The new lime-zeolite treatment plant for the Colorado River Aqueduct System of the Metropolitan Water District of Southern California will be built by the Griffith Company of Los Angeles. Low bidder of eight, Griffith Company will build the new plant at La Verne for $1,632,992.

(*Continued on page 13*)

PRESSURE REDUCING VALVE



1892 to 1935

Continuous automatic 24-hour service for 43 years. Inlet pressure 118 lbs. Outlet pressure 30 lbs.

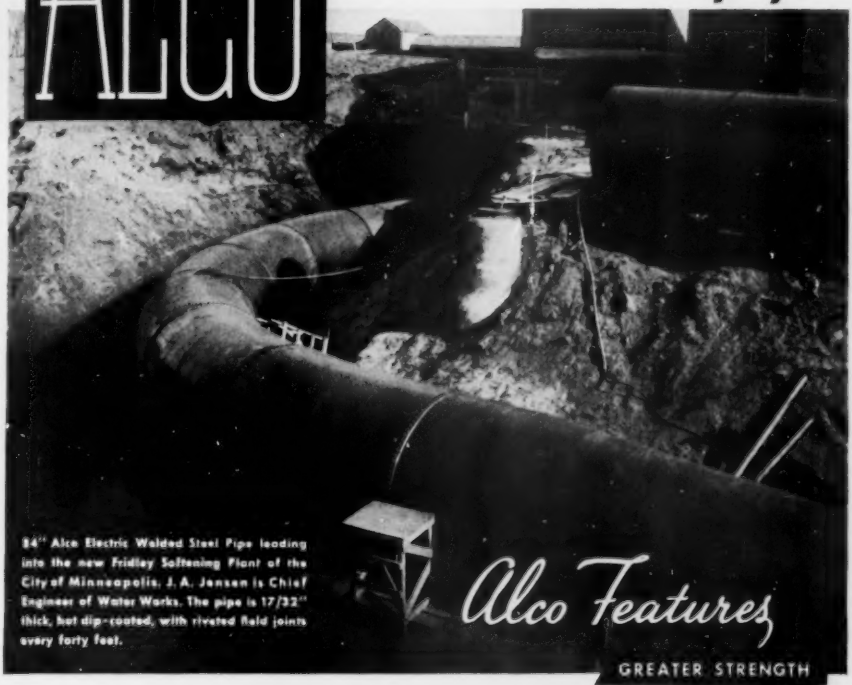
Because of extensions, removed and replaced by another Ross valve.

SIMPLE
RUGGED
COMPACT
DEPENDABLE
SINCE 1879

ROSS VALVE MFG. CO., INC.
TROY, N. Y.

ALCO

ELECTRIC WELDED *Steel pipe*



24" Alco Electric Welded Steel Pipe leading into the new Fridley Softening Plant of the City of Minneapolis. J. A. Jensen is Chief Engineer of Water Works. The pipe is 17/32" thick, hot dip-coated, with riveted field joints every forty feet.

Alco Features

GREATER STRENGTH
LONGER LIFE
SMOOTHER WATERWAY
LONGER LENGTHS
FEWER FIELD JOINTS
LOW INITIAL COST
ULTIMATE ECONOMY

• Since 1897 Minneapolis has been using steel pipe and now has more than 200,000 feet of it over 30" in diameter in water works and sewage service. All this pipe is in excellent condition. The maintenance cost during 41 years of service has been practically nil—no breaks, no shutdowns for repairs.

Why not be guided by the experience of this progressive city?

ALCO PRODUCTS

DIVISION OF

AMERICAN LOCOMOTIVE COMPANY
THIRTY CHURCH STREET NEW YORK, N. Y.

AMERICAN LOCOMOTIVE SALES CORP.
INCORPORATED IN U.S.A. WITH LIMITED LIABILITY
ARTILLERY HOUSE, ARTILLERY ROW, LONDON, S. W. 1, ENGLAND

LOW TOTAL COST

of operation has been the objective in developing

DE LAVAL *Centrifugal* PUMPS

● De Laval 12 in. pumps to handle 2080 g.p.m. each of sludge containing one per cent of solids.



THE INITIAL EFFICIENCY IS HIGH

and long sustained, primarily due to the De Laval Labyrinth Wearing Rings, which are used in all cases. As compared with older pumps, the higher efficiencies now obtained will repay the cost of De Laval Pumps in a short time. Renewable wearing parts are used at all points subject to wear. As the pumps are built to limit gages, these parts are interchangeable and renewals ordered by number can be installed at minimum expense and without delay.

Each pump guaranteed as to characteristics and operation and tested at our Works.

3201

DE LAVAL STEAM TURBINE COMPANY, TRENTON, N. J.

(*Continued from page 10*)

New Materials and Gadgets

1. **A new colorimeter** is on the market, designed for greater flexibility and narrower limits for reproducible results. It is claimed that the construction of the new colorimeter allows the use of a greater variety of sample holders and light filters, including monochromatic filters.

2. **Anti-freeze systems** for air lines have been developed for use with temporary air compressor installations or where electric current is not available; for use on permanent installations where electric current can be obtained; and for use for portable compressors.

3. **A new blueprinter** is on the market which uses a high pressure mercury quartz lamp. It is reported that a printing speed of 20 ft. per min. is attained with a current consumption of one-third that of a carbon arc machine of similar capacity.

4. **Where pure water** is a problem on the job, a new water bubbler which keeps 4 gal. of water cool all day may be the solution. It is made of stainless steel and designed for sanitary storage of drinking water.

5. **Bins for storage** of small parts are now available in seven sizes and two styles for arrangement either in straight rows or in semi-circles to suit findings of motion studies. Stored parts flow down into "tills" by gravity.

6. **For sealing dams,** ponds, ditches, etc., which have excessive leakage or seepage, a rare clay has been specially treated so that when spread over the surface it eliminates most of the seepage.

7. **An auto wheel dolly** has been developed for removing and replacing the heavy wheel assemblies on large trucks. It is also handy for moving the wheels from garage to repair bench.

8. **A portable bench grinder** is on the market. It weighs less than 9 lb. and has two $4\frac{3}{8}$ x $\frac{3}{8}$-inch grinding wheels. The over-all dimensions of the grinder are $10\frac{1}{4}$ x $6\frac{1}{2}$ x $6\frac{1}{2}$ in.

Readers can obtain further information by sending a postal to the A. W. W. A. headquarters giving the reference numbers of any of the above items and citing the December issue as the source.

(*Continued on page 15*)

Have you a *Safety First* CAMPAIGN in your community?

...*Kennedy* SAFETOPS *will help you*



SAFETOP means Safety First in fire hydrant design—safety to occupants of vehicles that may crash into the hydrants, safety from lengthy interruption to fire protection in case of breakage, and safety to the neighborhood in fire service.

If an automobile or truck should smash into a SAFETOP Hydrant, there is no likelihood of serious personal injuries, and no escape of water to block traffic or damage neighborhood property.

Instead, the patented Safety Breakable Section of the SAFETOP parts cleanly, and the hydrant can be returned to service within half an hour, without shutting off the water, and at a total cost of less than $10.00 for parts and labor.

In fire service, the simple, straight-line operating mechanism can always be depended upon to respond promptly, and the large standpipe and easy elbow and nozzle curves assure delivery of full main pressure into the hose.

For Safety First—and for safety at ALL times—you should insist on Kennedy SAFETOPS for your community.

Descriptive folder and prices on request.

The Kennedy Valve Mfg. Co., Elmira, N. Y.

KENNEDY
SAFETOP FIRE HYDRANT
REG. U.S. PAT. OFF.

OUR ZEOLITES—BASEX AND HI-BASEX

Perfection in highly refined, durable, efficient greensand zeolites for open gravity or closed pressure water softeners.

Extensively used with entire satisfaction for over 15 years

Send for Details

HUNGERFORD & TERRY, Inc., Clayton, New Jersey

also manufacturers of the well known INVERSAND water softener

(*Continued from page 13*)

Prizes for the three best papers on "What Attendance at the Annual Meetings of the A. W. W. A. has Meant to Me" are being offered by the Industrial Chemical Sales Division of the West Virginia Pulp and Paper Company. Prizes are: first, $50; second, $25; and third, $10.

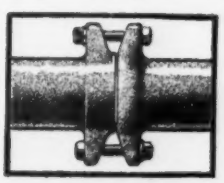
Papers on the subject are not to exceed 250 words and all submissions become the property of the Company. Judges will be three prominent men in the water works field whose decisions will be final. Anyone connected with the water works field is eligible except the Company's employees. Submissions must be postmarked prior to January 1, 1940 and should be addressed to: Contest Editor, Taste and Odor Control Journal, Industrial Chemical Sales Division, 230 Park Avenue, New York, N. Y.

Marlow Pumps has announced the appointment of Northrop & Company, Inc., 50 Church Street, New York, N. Y., as exclusive distributors for their line of pumps to water departments and water companies throughout the country. Marlow manufactures a complete line of self-priming centrifugal, diaphragm and sludge pumps and has pioneered in the portable centrifugal pump field. These pumps are made in sizes from $1\frac{1}{2}$- to 10-inch and are equipped with four-cycle engines.

(*Continued on page 16*)

UNIVERSAL CAST IRON PIPE

LAID WITH JUST WRENCHES





No other tools are needed. No lead, no pouring, no bell holes to dig. Machined iron-to-iron flexible joints. SPEEDIEST...EASIEST ...SAFEST. Highest quality Cast Iron.

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CHICAGO, ILL., 1105 W. 36th St. - OAKLAND, CALIF., 278 Fourth St.

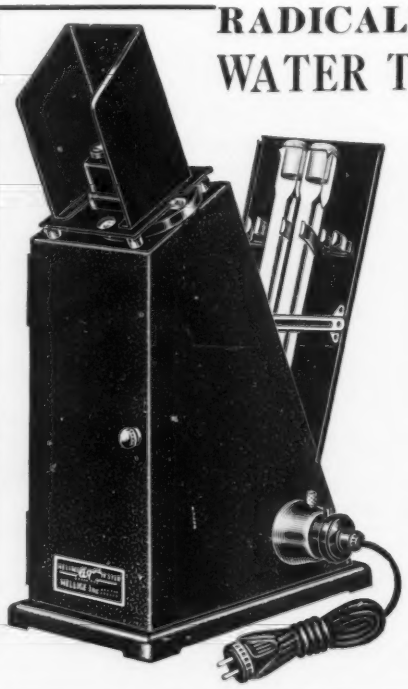
OFFICES IN PRINCIPAL CITIES COAST TO COAST

(*Continued from page 15*)

Transite is now used as a basic material in partitions for subdividing offices and plants. Transite, developed by Johns-Manville, New York, is composed of asbestos and cement. Original erection and relocation are both claimed to be easy and simple due to ingenious connectors. The walls are only $1\frac{3}{4}$ in. thick, but due to the nature of the material great resistance to noise and fire is claimed.

The old Hippodrome Theatre at Sixth Avenue and Forty-fourth St. in New York staged one last crashing climax recently as it was being demolished, a crash that broke a 4-inch water main cutting off the supply to the Hotel Algonquin and caused a 10-inch main feeding several other hotels and buildings to be cut off. A sizeable district was without a normal water supply for six hours. A huge crane operating from within the skeleton of the building was tearing chunks from the 20-inch thick wall when the middle of the wall suddenly buckled outward at its middle, toppling tons of debris into the street. The street had been closed to traffic and the greatest injury was that to the water main. The old playhouse will soon be gone and a parking garage is expected to take its place.

(*Continued on page 18*)



RADICALLY IMPROVED
WATER TEST COMPARATOR

The new Hellige Aqua Tester combines the thoroughly demonstrated advantages of Hellige *non-fading glass color standards* with radical improvements in design. This new model is, we believe, the most advanced type ever brought on the market and demands special consideration as it brings to its user the utmost in permanent reliability, accuracy, convenience and, last but not least, economy. Standards for all popular A. P. H. A. and A. W. W. A. Methods and Hydrogen Ion Control are available.

Write for Bulletin No. A-611.

HELLIGE
INCORPORATED
3718 NORTHERN BLVD. LONG ISLAND CITY, N.Y.

GRAPH & NOMOGRAM

from

Charles P. Hoover's

Practical Application of the Langelier Method

Jour. A. W. W. A., 30: 1820 (1938)

An indispensable aid to every sanitary engineer and chemist.

Hundreds of copies distributed since publication.

Issued flat, unbound, unaccompanied by text matter.

Nominal charge of ten cents per copy to cover costs of printing and mailing. Send stamps or coin with order.

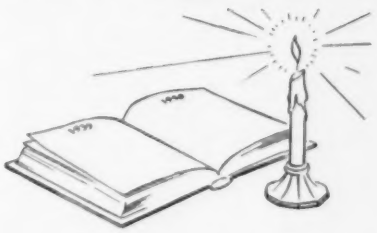
Address The

American Water Works Association

22 East 40th Street

New York City

An account that's never closed



WE'RE about to close another year—balance our books, take our inventory, prepare a report to our stockholders.

But there's one account we never close out—one we can't enter, audit—and then forget. That account is friendship.

So to our friends—simply and sincerely—our appreciation, and our every warm wish for a Merry Christmas and a better New Year.

NATIONAL METER COMPANY
4207 First Avenue, Brooklyn, N. Y.
BOSTON • CHICAGO • DALLAS
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NATIONAL *Meters*

(*Continued from page 16*)



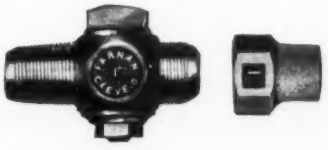
How straight pipe was curved in the field is shown in the accompanying photo. In Milford, N. H. the right of way from the reservoir to the town was laid out perfectly straight and the pipe bought for the job. But by the time the pipe came, last minute changes necessitated laying a wide curve in the line. Procuring special orders of curved pipe would have delayed and increased the cost of the job. The problem was solved on the site by sawing standard 13-foot lengths of "Century" Asbestos-Cement Pipe into three equal smaller lengths. The smaller, straight pieces were coupled with standard "Century" flexible couplings and the curve was negotiated without the use of any elbows or bends.

(*Continued on page 20*)

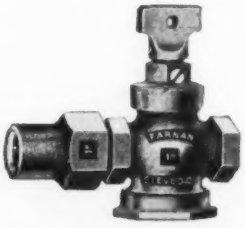
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Established in the Water Works Field since 1852.

Continued acceptance throughout 87 years of satisfactorily meeting Water Works requirements is your Proof.



FARNAN Quality and Durability



All our products are accurately machined to gauges and Tested at 200 lbs. Hydrostatic Pressure.

THE FARNAN BRASS WORKS CO.

CLEVELAND *EST. 1852* **OHIO**

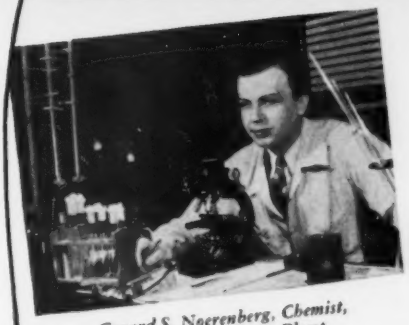
MATHIESON SANITATION SERVICE *Proves its worth* TO MODERN WILMETTE, ILLINOIS

. . . Says Gerard S. Noerenberg, Chemist, Wilmette Filtration Plant

"We have been users of your Chlorine for about nine years with an intermediate gap when we used another source of supply. This experience (sticky valves) fully confirmed our belief that Mathieson service is both dependable and advantageous to us. Your product has been uniformly good. There has been no trouble with sticky valves.

"We also use HTH in its convenient packaged form, in a number of ways. It is used as a stand-by emergency source of Chlorine in our Filtration Plant, to sterilize all new mains and reservoirs and as a health help in the prevention of Athlete's Foot in the Waterworks locker room. The public bathing beach has been using HTH for years in the showers and locker rooms. In the outlying districts, HTH is used in the sterilization of wells.

"Not the least of advantages in using your products has been the friendly, constant and able assistance given us by your representative, who stops in on us frequently."



Gerard S. Noerenberg, Chemist, Wilmette Filtration Plant



Lake Michigan Filtration Plant, Wilmette, Illinois.

● Whether the job in hand be water purification, sewage treatment or swimming pool sanitation, you have a right to expect a dependable supply of liquid chlorine—a pure product, trouble-free containers and valves, prompt delivery service. It is because Mathieson Chlorine has proved itself in these three essentials that so many communities like Wilmette, Illinois specify "Mathieson" when there is a chlorinating job to be done.

Mathieson Chlorine, coupled with free-flowing HTH for special and emergency jobs that so often arise, make a team hard to beat for dependable sanitation service.



HTH comes in 5-lb. cans with replaceable caps, packed 9 cans to the case; also in 75-lb. drums.

THE Mathieson Alkali Works (INC)

60 EAST 42ND STREET, NEW YORK, N. Y.

LIQUID CHLORINE · HTH · SODA ASH · CAUSTIC SODA · BLEACHING POWDER · BICARBONATE OF SODA · AMMONIA, ANHYDROUS and AQUA · PH-PLUS FUSED ALKALI · DRY ICE · CARBONIC GAS

(*Continued from page 18*)

The Town of Lake, Milwaukee County, Wisconsin, is completing a monumental municipal service building, which houses completely a million-gallon tank and tower, council chambers, city official offices, street cleaning department, and zeolite softening plant. The building is situated in a five-acre landscaped park at the end of a boulevard approached from the town proper.

Public relations has its sunny side—as is again appropriately reported from California in *The Intake*, November, 1939, publication for employees of the Los Angeles City-owned Department of Water and Power. Under the heading "Employee Courtesy Pays Dividends," the following occurs:

"Referring to the *Official Bulletin* and *Your Garden* publications that are enclosed with Department bills, W. G. Cline wrote as follows:

" 'I want to thank you for the bit of history re the Owens River water and power development that comes each month; also the garden data. Coming to California in 1876 when we used to haul water in wagon tanks, knowing people to kill each other over water rights and law suits many, Owen River water and power progress interests me greatly. So, many

(*Continued on page 22*)

CLEAN YOUR WATER MAINS

One does not have to be an expert mathematician to figure out that a clogged water main calls for a stronger pressure and that in turn calls for more coal—and literally burning up money. We can show you how to get dollar for dollar value out of every ton of coal. We can show you how to clean the water mains quickly and cheaply. Send us your address—that's all we ask of you.

National Water Main Cleaning Co.

50 Church St., New York, N. Y.

BRANCHES

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910 William-Oliver Bldg., Atlanta, Ga.
7103 Dale Ave., St. Louis, Mo.
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2587 Glen Echo Drive, Columbus, Ohio
501 Howard St., San Francisco, Calif.
58 Pelham Ave., Toronto, Canada.

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Means...

PROVED
DEPENDABLE
MATERIAL

Properly Designed and Manufactured







. . . This has been true for over forty years. • In the building of Elevated Steel Tanks — as in all its manufacturing activities, Pittsburgh-Des Moines achieves the ideal of *Quality . . . at Lowest Cost*. Quality in intelligent design . . . quality in materials, full weight and honestly fabricated . . . quality in workmanship and erection —*at lowest cost to you* by means of modern efficiency in manufacture and the plain "know-how" of experience. Are Elevated Steel Tanks a present concern of yours? P·DM maintains a complete engineering advisory service at the disposal of any interested authority, without obligation. For a consultation, write to our nearest office—and ask for your copy of P·DM's 20-page "Modern Water Storage" Bulletin!

PITTSBURGH • DES MOINES STEEL CO.
PITTSBURGH, PA. 3424 NEVILLE ISLAND
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CHICAGO . . . 1228 FIRST NATIONAL BANK BUILDING
DALLAS . . . . . 1229 PRAETORIAN BUILDING
SAN FRANCISCO . . . . . 631 RIALTO BUILDING

(*Continued from page 20*)

thanks. I hope some day you will run excursions so we can see this wonderful project from start to finish.'

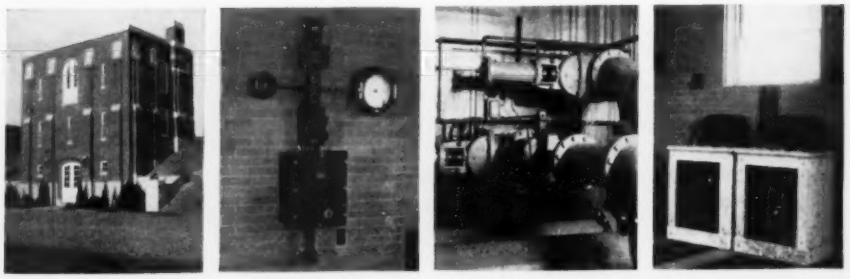
"Addressed to R. R. Robertson, engineer of construction who is supervising the building of the new third power circuit from Boulder Dam for the Bureau of Power and Light, the following letter from R. D. Stowell speaks for itself:

" 'I wish to thank you again for the courtesies that you have extended me in permitting me to trespass over the Bureau of Power and Light roads in the San Gabriel Mountains and for the traverse of the road which you so kindly sent me.

" 'To be quite candid with you, I never expected such cooperation from any civil bureau as I have received from you, and I shall never cease telling people of your wonderful treatment.'

"Communications of this type are an inspiration and a challenge to every Department employee. As public employees we are constantly 'on the spot.' There is an element of the public that always is ready to criticize us on the slightest provocation or on no provocation at all. We, therefore, to a far greater degree than private business employees,

(*Continued on page 26*)



Complete Satisfaction

as expressed by those in charge of the *Greenfield, Mass. Water Works is typical of expressions heard wherever Builders metering and controlling equipment is installed, whether it is a large, small, or medium size plant. Illustrations above (left to right) show the Greenfield Filter plant; the Chronoflo Recorder and Totalizer registering flow through a 16" x 5¼" Venturi Tube; Venturi Controller Tube in the filter gallery, and the Builders Gauge with rate-setting knobs for the Controller. Whatever your water works, or sewerage, metering and control problems may be, it will pay you well to specify "Builders."

*Consulting Engineers, Weston & Sampson
Superintendent, H. L. Field

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(Continued from page 22)

must perform our duties with that extra measure of consumer cooperation that will inspire even the severest critic to forget his preconceived antipathy toward public employees and feel compelled to pat us on the back for a 'good job, well done.' "

Certification of operators is in progress in Tennessee. On October 6 the Tennessee Department of Public Health sent application forms to all water works plant operators in the state. Tennessee has a voluntary certification plan under which the operators signify their willingness to be tested and then are scheduled for a test which is usually administered in conjunction with an operator's short school.

Examinations for applicants were given at the Ninth Annual School for Water Works Plant Operators held at the University of Tennessee in Knoxville on November 13–17. These examinations were primarily for Groups A and B for the entire state and for Groups C and D from the proximity of Knoxville. In addition to the course at Knoxville, supplemental schools covering a period of two days and held in Nashville and Jackson permitted operators of C and D Groups to obtain the necessary

(Continued on page 28)

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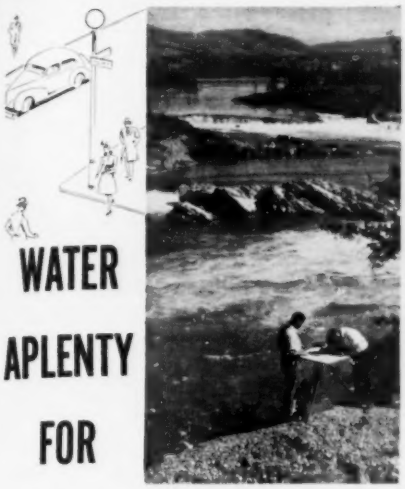
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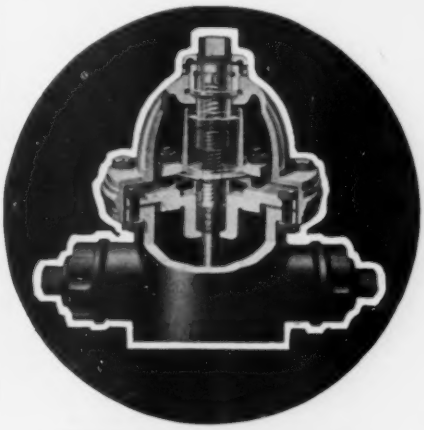
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Write for Literature

(*Continued from page 26*)

instruction without being absent from their plants for too great a period. Preliminary reports show that more than 50 per cent of the state's operators have availed themselves of this opportunity.

Group A comprises filtration plant operators in towns of over 15,000 population. Group B covers filtration plant operators of supplies for 2–15,000 population, or chlorination for more than 15,000. Group C includes operators of filtration plants for less than 2,000 population, or for chlorination for less than 15,000. Group D is for operators where there is no treatment. Certain educational qualifications are required for the different groups. Operators in Tennessee should submit an application to the Tennessee Dept. of Public Health immediately, for certain of the educational qualifications are waived provided the application is filed before January 1, 1940.

(*Continued on page 30*)

Willard C. Lawrence, Acting Commissioner of Water and Heat, Cleveland, Ohio, died on November 15 of a heart ailment. He was 54 years old and had been an employee of the Cleveland Department of Public Utilities for 32 years. He was appointed city water commissioner in October, 1938, after being superintendent of the Baldwin Filtration Plant and Division Avenue Pumping Station.

Mr. Lawrence, a member of the A. W. W. A. since 1926, was the recipient of the Fuller Memorial Award for the Ohio Section in 1939.

Through the medium of these columns, Mr. Lawrence's family express their appreciation of the many messages and tributes received by them at the time of his death.

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(*Continued from page 28*)

Autograph hunters are advised by E. G. McCreery in "Water Lines", publication for and by employees of the Indianapolis Water Company, to "haunt the cashiers' windows if they seek celebrities. Among the notables who fill our tills each month are Julius A. Caesar, Edgar A. Poe, George Washington, and Andrew Jackson. The stage is represented by Walter Huston; the radio by George Burns. Then we have Miss Indiana Guard, that horticulturistic Loving D. Rose, budgetting Lizzie Purse, and agricultural C. Pigg."

Pardeeville, Wisconsin, population 873, has just completed installation of a complete water works system, including wells, pumps, tank and tower, zeolite water softener and distribution system, at a cost of $93,000.

(*Continued on page 36*)

(*Continued from page viii*)

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GIBSON, LEE. Water Plant Operator, Albany, Tex.
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GLEESON, L. T. Supt., Water Dept., Ferris, Tex.
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GREENE, R. T. Clerk & Treas., Black Mountain, N. C.
GRESHAM, HILL C. Genl. Mgr., S. W. Water Works Journal, Temple, Tex.
GUDE, GEORGE E., JR. Mgr. of Sales, Wyatt Metal & Boiler Works, Houston, Tex.
HARRELL, H. O. Water Supt., El Reno, Okla.
HARRIS, J. C. Water Supt., Electra, Tex.
HARRISON, CECIL H. Chief Engr., City Water Dept., P.O. Box 122, Enid, Okla.
HAYNES, LAWSON. Plant Supt., W. Va. Water Service Co., 715 Indiana Ave., Charleston, W. Va.
HILTON, HARRY. Supt., Water Dept., Cordell, Okla.
HORNER, J. L. Supt., Water Dept., Henderson, Tex.
JESSEE, VINCE. Supt., Water Dept., 630 East E. St., Elizabethton, Tenn.
JAMES, A. M. City Secy., Hillsboro, Tex.
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KILKENNY, T. D. City Engr., City Hall, Vallejo, Calif.
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LEDBETTER, CHARLES M. San. Engr., State Board of Health, Jackson, Miss.
LEWIS, C. D. Water Supt., Ennis, Tex.
LLOYD, J. M. Supt., Water Dept., 1201 S. Sneed St., Tyler, Tex.
LONG, V. V. V. V. Long & Co., Cons. Engrs., 1300 Colcord Bldg., Oklahoma City, Okla.
MALONE, J. R. Chemist, Durham Water Dept., 1312 N. Gregson St., Durham, N. C.
MCAFEE, H. D. San. Engr., City Water Dept., City Hall, Corsicana, Tex.
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(*Continued on page 32*)


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Morrison, James E. Purification Engr., Seattle Water Dept., Rt. #1, Box 173, Renton, Wash.
Morrison, R. J. Chief Meter Inspector, Dallas City Water Works, Dallas, Tex.
Mowlam, Wm. V. City Engr., Box 593, Corsicana, Tex.
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Nelson, Herbert M. Acting Purchasing Agent, East Bay Mun. Utility Dist., 512—16th Street, Oakland, Calif.
Newland, S. H. State Health Dept., 225 Albany, Shreveport, La.
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O'Donnell, J. J. Supt., Water Dept., Bossier City, La.
Owens, J. E. Asst. Water Supt., Henderson, Tex.
Perry, Henry O. Electrical Worker, Detroit Dept. of Water Supply, 8300 W. Warren Ave., Dearborn, Mich.
Pinner, John A., Jr. Supt., Water Dept., Brookfield, Ill.
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(*Continued on page 34*)

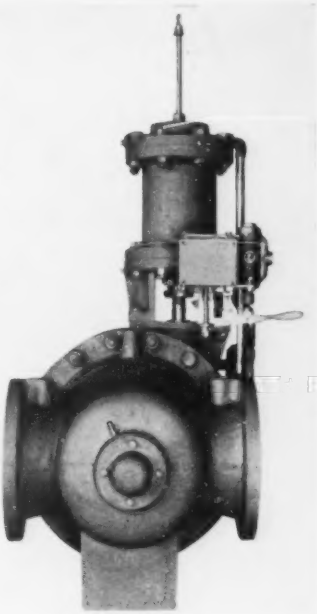
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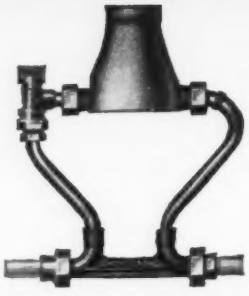
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SANDERS, W. H. Operator, Water Works, Prosper, Tex.
SHOCKLEY, H. R. Mgr., Water Dept., Gladewater, Tex.
SHORE, JOHN, JR. Mechanical Supt., Beacon Mfg. Co., P.O. Box 22, Swannanoa, N. C.
SHURLEY, M. I. Supt., Water Dept., 210 So. Bullet, Holdenville, Okla.
SLOAN, JOE. Supt. of Water Dept., Waynesville, N. C.
SMITH, MOULTRIE. Supt., Water Dept., City Hall, Nacogdoches, Tex.
SPENCER, W. R. Prof. of Civil Eng., University of Arkansas, Fayetteville, Ark.
STEENSON, H. D. Secy., Water Works, Plano, Tex.
SWANSON, J. L. Water Purification Supt., 2238—18th St., Port Arthur, Tex.
TAYLOR, ALEX. O. Director, Eng. Extension, Ala. Poly Inst., Box 70, Auburn, Ala.
TAYLOR, R. A. Repr., Layne-Texas Co., 4915 Abbott St., Dallas, Tex.
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WALKER, JOHN A. Water & Electrical Supt., Stroud, Okla.
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WATSON, PAT. Supt., Colfax Mun. Water Works, Colfax, La.
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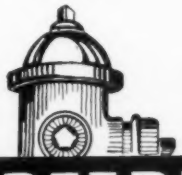
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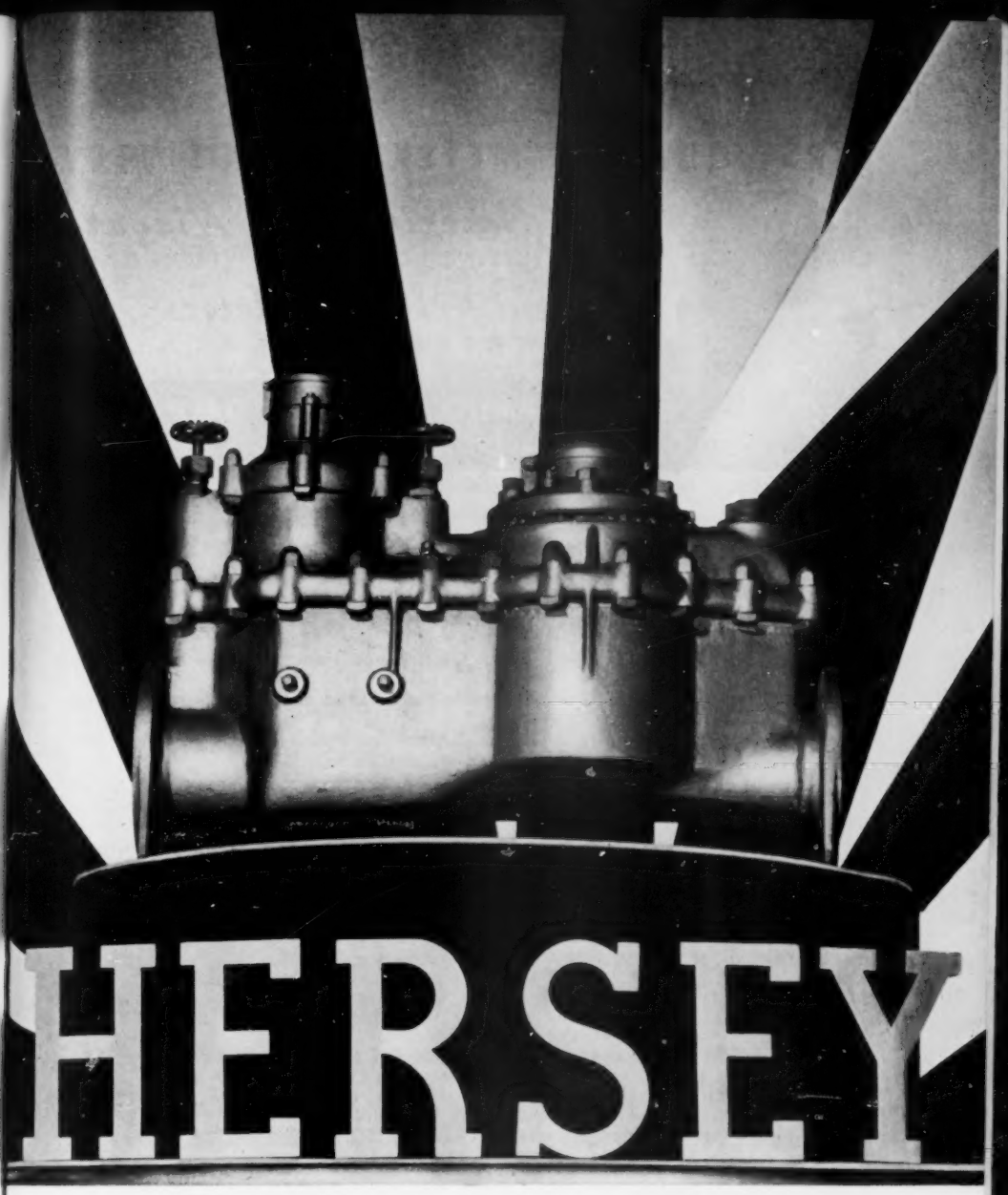
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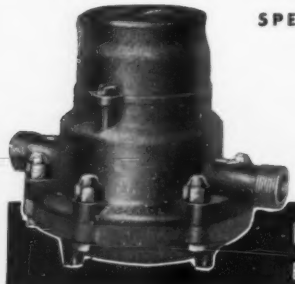
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"**Meter Pete the Reader**" is the hero of a song written by a staff member of the Hackensack Water Company. As published below and sung to the tune of "Barnacle Bill the Sailor," it is a favorite at Hackensack Water Company dinner meetings:

(*Continued on page 38*)

A.W.W.A.

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A fine newly designed parchment paper mempership certificate for A. W. W. A. members is now available in 9 by 12 inch size, suitable for framing.

Send your name—exactly as you wish it to appear—and enclose 40¢ in coins or postage to cover cost of lettering and mailing.

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A DEPENDABLE SELF - CAULKING JOINT COMPOUND

COOK Well Strainers

A reciprocal relation, the life and functioning of the one depending much on the other.

A. D. COOK, INC.
Lawrenceburg - Indiana

COOK Deep-Well Turbine Pumps

(*Continued from page 36*)

1

"Who's that knocking at my door?
Who's that knocking at my door?
Who's that knocking at my door?,"
Cried the household owner.

"It's only me, as well you knew,"
Said Meter Pete, the Reader.
"I've come to read your meter true,"
Said Meter Pete the Reader.
"I'll read it quick and read it slick
I'm sure the bill will make you sick.
If you don't like it you can kick,"
Said Meter Pete, the Reader.

2

"I'll come down and let you in,
I'll come down and let you in,
I'll come down and let you in,"
Cried the household owner.

"Well hurry before I bust in the door,"
Said Meter Pete the Reader.
"I'll rare and tare and rant and roar,"
Said Meter Pete the Reader.
"Do you think that I will wait all day?
How do you think I earn my pay?
If you don't hurry I'll go away,"
Said Meter Pete the Reader.

3

"When shall I see you again?
When shall I see you again?
When shall I see you again?,"
Cried the household owner.

"In three months time I'll come again,"
Said Meter Pete the Reader.
"I hope you see that I get in,"
Said Meter Pete the Reader.

(*Continued on page 39*)

(*Continued from page 38*)

"Be sure to stay at home that date;
Try not to roam and stay out late,
For if you do I'll estimate,"
Said Meter Pete the Reader.

4

"I'll be here when you arrive,
I'll be here when you arrive,
I'll be here when you arrive,"
Cried the household owner.

"Well if you are, have the door ajar,"
Said Meter Pete the Reader.
"An open door is the best by far,"
Said Meter Pete the Reader.
"I'll skip right in and skip right out;
Your meter's read without a doubt,
And I hope that you'll get the gout,"
Said Meter Pete the Reader.

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Everybody Likes Activated Alum

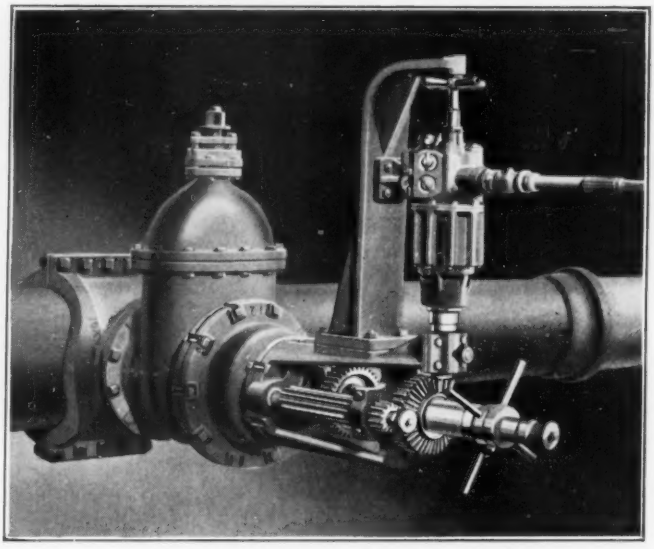
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R. D. Wood Co.
Swimming Pool Refiltration System:
American Water Softener Co.
Everson Mfg. Co.
Hungerford & Terry, Inc.
International Filter Co.
Permutit Co.
Swimming Pool Sterilization:
Everson Mfg. Co.
Permutit Co.
Wallace & Tiernan Co., Inc.
Tanks, Elevated Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Company
Pittsburgh-Des Moines Steel Co.
Tanks, Mixing:
Alco Products Div., Am. Loco. Co.
Chicago Bridge & Iron Company
Pittsburgh-Des Moines Steel Co.
Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Company
Pittsburgh-Des Moines Steel Co.
Tapping Machines:
Mueller Co.
A. P. Smith Mfg. Co.
Taste and Odor Removal Plants:
Hungerford & Terry, Inc.
Industrial Chemical Sales
International Filter Co.
Permutit Co.
Taste Removal:
Cliffs Dow Chemical Co.
Industrial Chemical Sales
International Filter Co.
Wallace & Tiernan Co., Inc.
Turbidimeters:
Hellige, Inc.
Wallace & Tiernan Co., Inc.
Turbines, Steam:
DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.
Turbines, Water:
DeLaval Steam Turbine Co.
S. Morgan Smith Co.
Valve Boxes:
Central Foundry Co.
Crane Co.
Ford Meter Box Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Valve Inserting Machines:
A. P. Smith Mfg. Co.
Valves, Altitude:
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Check, Flap, Foot, Hose, Mud and Plug:
A. D. Cook, Inc.
Crane Co.
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.
Grinnell Co.

Valves, Float:
Crane Co.
Ludlow Valve Mfg. Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Gate:
Crane Co.
Dresser Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Alco Products Div., Am. Loco. Co.
Crane Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
Mueller Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Relief (Temperature and Pressure):
Crane Co.
Kitson Co.
Mueller Co.
S. Morgan Smith Co.

Valves, Swing Check:
Crane Co.
Grinnell Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Uniflow Check (for Double Check Service):
Grinnell Co.

Valves, Water Meter Protection:
Crane Co.
Kitson Co.

Water Softener (Hot Lime Soda):
American Water Softener Co.
International Filter Co.
Permutit Co.

Water Softener (Zeolite):
Hungerford & Terry, Inc.
International Filter Co.
Permutit Co.

Water Softening Plants:
American Water Softener Co.
Chicago Bridge and Iron Company
Everson Mfg. Co.
Fuller & Everett
Hungerford & Terry, Inc.
International Filter Co.
Permutit Co.
Pittsburgh-Des Moines Steel Co.

Water Sterilization:
Calgon, Inc.

Water Supply Contractors:
A. D. Cook, Inc.

Water Testing Apparatus:
Everson Mfg. Co.
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Water Softener Co.
Everson Mfg. Co.
Hungerford & Terry, Inc.
International Filter Co.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Wallace & Tiernan

Water Waste Detection:
Builders Iron Foundry
Pitometer Co.

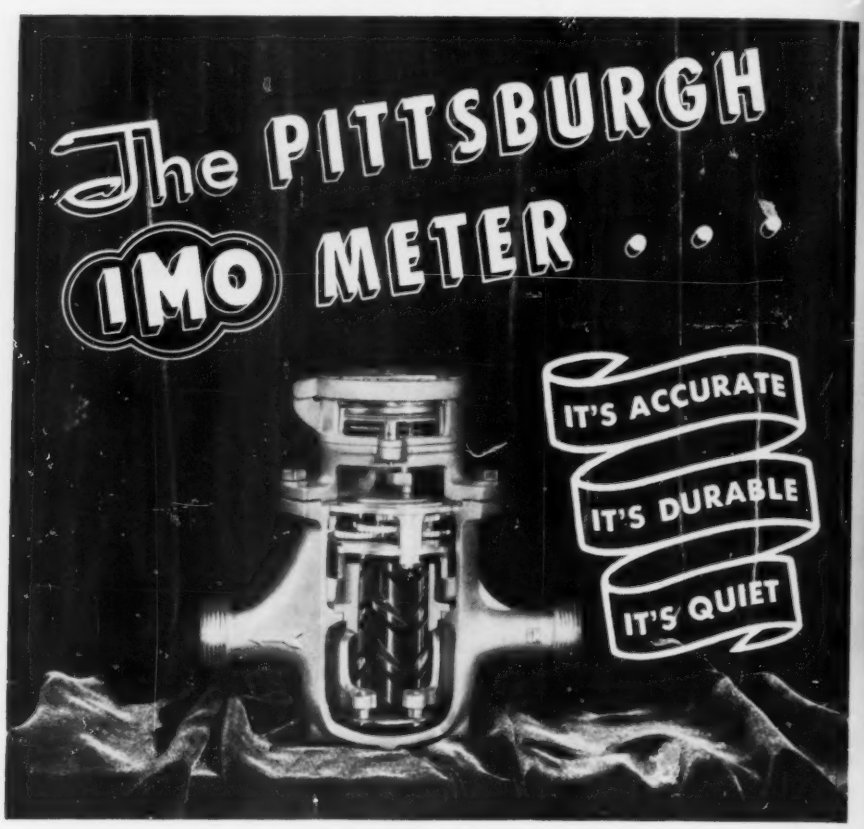
Water Works Construction, General:
Pittsburgh-Des Moines Steel Co.

Well Drilling Contractors:
A. D. Cook, Inc.

Well Screens:
A. D. Cook, Inc.
Crane Co.

Wrenches, Ratchet:
Crane Co.
Dresser Mfg. Co.

Zeolite Water Softeners:
American Water Softener Co.
Hungerford & Terry, Inc.
International Filter Co.
Permutit Co.



BECAUSE it is built to specifications which guarantee an accuracy of 98% at 1/4 g.p.m. and 90% at 1/12 g.p.m., the Pittsburgh IMO Water Meter accurately measures those flows that either escape measurement entirely, or are only partially recorded by conventional meters. And what is even more important, this remarkable accuracy is sustained. Numerous tests show that even after several million gallons have been measured, Pittsburgh IMO Meters measure slightly better on the low flows than when first put into service, and that their accuracy does not change at rates of flow above 1 g.p.m.

Not only do Pittsburgh IMO Meters increase revenue by accurate measurement, but their maintenance costs are unusually low. The unique design of the measuring chamber and its semi-floating rotors increases the life of the working parts as compared with conventional meters and insures longer, trouble-free service.

The smoothly turning rotors, precision cut to mesh perfectly, revolve with a semi-floating action as the water flows through the measuring chamber in a straight line. For this reason the Pittsburgh IMO Meter can never become noisy; there can be no "clicking" noise to annoy your consumers. Write for the complete story in Bulletin W-529.

PITTSBURGH EQUITABLE METER COMPANY
MERCO NORDSTROM VALVE CO.
NEW YORK BUFFALO PHILADELPHIA Main Offices PITTSBURGH, PA DES MOINES CHICAGO COLUMBIA
KANSAS CITY TULSA LOS ANGELES MEMPHIS OAKLAND HOUSTON

Remember PITTSBURGH IMO METERS WEAR IN WHERE OTHERS WEAR OUT



Scene on 48" all Dresser-coupled steel transmission line constructed in early part of 1938, under supervision of Newark, (N. J.) Bureau of Water officials, from Belleville Reservoir to the North Newark city line.

In NEWARK as elsewhere!

Now Newark, busy New Jersey metropolis, installs an all-Dresser-coupled water line! Size: 48"; test pressure: 200 lbs. per sq. in. with all couplings bottle-tight; reasons for Dresser-coupling this line: tightness, flexibility, simplicity, speed, and TRUE economy! Line was backfilled promptly as laying progressed.

A METROPOLITAN TREND!

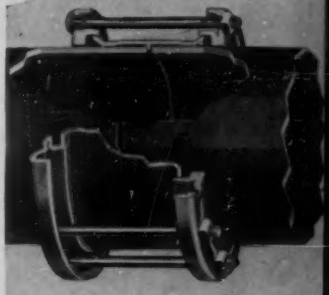
Many large and important cities are Dresser-coupled users. To mention a few:

Buffalo, N.Y. — Philadelphia, Pa.
Cleveland, Ohio — San Francisco, Cal.
Detroit, Mich. — St. Louis, Mo.

FIVE REASONS WHY MODERN WATER LINES ARE DRESSER-COUPLED:

1. **PERMANENT TIGHTNESS**—proved for 90 years, on 250,000 miles of pipe.
2. **FLEXIBILITY**—normal pipe movements—present in every line—are absorbed.
3. **SIMPLICITY**—joints are "factory-made"; ordinary labor can install.
4. **STRENGTH**—predetermined; joints safely withstand any specified pressure.
5. **TRUE ECONOMY**—a truly lower joint cost throughout the life of the line.

Write for our General Catalog No. 36.



Cutaway view of Dresser Coupling Style 38, showing working principle. Note that plain-end pipe is used. The *resilient* rubber-compound gaskets flexing with the pipe, safely absorb pipe movements, thus preventing failures that often occur with rigid joints.

THE MODERN TREND IS TO DRESSER COUPLINGS

DRESSER MFG. COMPANY, BRADFORD, PA. • 230 Park Avenue, New York, N.Y. • Peoples Gas Building, Chicago, Ill. • Shell Building, Houston, Tex.
1032 Polk Street, San Francisco, Calif. • *In Canada:* Dresser Mfg. Company, Ltd., 60 Front Street, West, Toronto, Ontario

LEADITE

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight, durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 30 years.
Saves at least 75%



THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking

